Committee for Risk Assessment

RAC

Annex 1
Background document
to the Opinion proposing harmonised classification and labelling at EU level of

Sodium chlorate

EC Number: 231-887-4
CAS Number: 7775-09-9

CLH-O-0000007009-75-01/F

The background document is a compilation of information considered relevant by the dossier submitter or by RAC for the proposed classification. It includes the proposal of the dossier submitter and the conclusion of RAC. It is based on the official CLH report submitted to consultation. RAC has not changed the text of this CLH report but inserted text which is specifically marked as 'RAC evaluation'. Only the RAC text reflects the view of RAC.

Adopted

10 June 2021

CLH report

Proposal for Harmonised Classification and Labelling

**Based on Regulation (EC) No 1272/2008 (CLP Regulation),
Annex VI, Part 2**

International Chemical Identification: Sodium chlorate

EC Number: **231-887-4**

CAS Number: **7775-09-9**

Index Number: **017-005-00-9**

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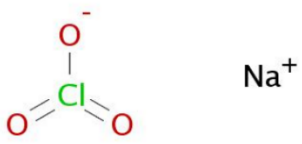
1 IDENTITY OF THE SUBSTANCE

1.1 Name and other identifiers of the substance

Table 1: Substance identity and information related to molecular and structural formula of the substance

Name(s) in the IUPAC nomenclature or other international chemical name(s)	Sodium chlorate
Other names (usual name, trade name, abbreviation)	/
ISO common name (if available and appropriate)	/
EC number (if available and appropriate)	231-887-4
EC name (if available and appropriate)	Sodium chlorate
CAS number (if available)	7775-09-9
Other identity code (if available)	/
Molecular formula	ClHO3.Na
Structural formula	
SMILES notation (if available)	[Na+].[O-]Cl(=O)=O
Molecular weight or molecular weight range	106.441 g/mol
Information on optical activity and typical ratio of (stereo) isomers (if applicable and appropriate)	Not applicable
Description of the manufacturing process and identity of the source (for UVCB substances only)	Not applicable
Degree of purity (%) (if relevant for the entry in Annex VI)	

1.2 Composition of the substance

Table 2: Constituents (non-confidential information)

Constituent (Name and numerical identifier)	**Concentration range (% w/w minimum and maximum in multi-constituent substances)**	**Current CLH in Annex VI Table 3.1 (CLP)**	**Current self-classification and labelling (CLP)**
Sodium chlorate EC no.: 231-887-4	**>=98.0%**	**Oxid. Solid 1; H271 Acute Tox. 4; H302 Aquatic Chronic 2; H411**	

Table 3: Impurities (non-confidential information) if relevant for the classification of the substance

Impurity (Name and numerical identifier)	Concentration range (% w/w minimum and maximum)	Current CLH in Annex VI Table 3.1 (CLP)	Current self-classification and labelling (CLP)	The impurity contributes to the classification and labelling

Table 4: Additives (non-confidential information) if relevant for the classification of the substance

Additive (Name and numerical identifier)	Function	Concentration range (% w/w minimum and maximum)	Current CLH in Annex VI Table 3.1 (CLP)		Current self-classification and labelling (CLP)	The additive contributes to the classification and labelling
	No additives					

2 PROPOSED HARMONISED CLASSIFICATION AND LABELLING

2.1 Proposed harmonised classification and labelling according to the CLP criteria

Table 5:

	Index No	International Chemical Identification	EC No	CAS No	Classification		Labelling			Specific Conc. Limits, M-factors	Notes
					Hazard Class and Category Code(s)	Hazard statement Code(s)	Pictogram, Signal Word Code(s)	Hazard statement Code(s)	Suppl. Hazard statement Code(s)		
Current Annex VI entry	017-005-00-9	Sodium chlorate	231-887-4	7775-09-9	Ox. Sol. 1 Acute Tox. 4 * Aquatic Chronic 2	H271 H302 H411	GHS03 GHS07 GHS09 Dgr	H271 H302 H411			
Dossier submitters proposal	017-005-00-9	Sodium chlorate	231-887-4	7775-09-9	Remove Aquatic Chronic 2 Modify Acute Tox. 3	Remove H411 Modify H301	Remove GHS09 Modify GHS06	Remove H411 Modify H301		**Add** oral; ATE = 100 mg/kg bw	
Resulting Annex VI entry if agreed by RAC and COM	017-005-00-9	Sodium chlorate	231-887-4	7775-09-9	Ox. Sol. 1 Acute Tox. 3	H271 H301	GHS03 GHS06 Dgr	H271 H301		oral; ATE = 100 mg/kg bw	

Table 6: Reason for not proposing harmonised classification and status under public consultation

Hazard class	Reason for no classification	Within the scope of public consultation
Explosives	Hazard class not assessed	No
Flammable gases (including chemically unstable gases)	Hazard class not assessed	No
Oxidising gases	Hazard class not assessed	No
Gases under pressure	Hazard class not assessed	No
Flammable liquids	Hazard class not assessed	No
Flammable solids	Hazard class not assessed	No
Self-reactive substances	Hazard class not assessed	No
Pyrophoric liquids	Hazard class not assessed	No
Pyrophoric solids	Hazard class not assessed	No
Self-heating substances	Hazard class not assessed	No
Substances which in contact with water emit flammable gases	Hazard class not assessed	No
Oxidising liquids	Hazard class not assessed	No
Oxidising solids	Hazard class not assessed	No
Organic peroxides	Hazard class not assessed	No
Corrosive to metals	Hazard class not assessed	No
Acute toxicity via oral route	Harmonised classification proposed	Yes
Acute toxicity via dermal route	Hazard class not assessed	No
Acute toxicity via inhalation route	Hazard class not assessed	No
Skin corrosion/irritation	Hazard class not assessed	No
Serious eye damage/eye irritation	Hazard class not assessed	No
Respiratory sensitisation	Hazard class not assessed	No
Skin sensitisation	Hazard class not assessed	No
Germ cell mutagenicity	Hazard class not assessed	No
Carcinogenicity	Hazard class not assessed	No
Reproductive toxicity	Hazard class not assessed	No
Specific target organ toxicity-single exposure	Hazard class not assessed	No
Specific target organ toxicity-repeated exposure	Hazard class not assessed	No
Aspiration hazard	Hazard class not assessed	No
Hazardous to the aquatic environment	Harmonised classification proposed	Yes
Hazardous to the ozone layer	Hazard class not assessed	No

3 HISTORY OF THE PREVIOUS CLASSIFICATION AND LABELLING

Sodium chlorate was introduced in the Annex I by Commission Directive 93/72/EEC of 1 September 1993 adapting to technical progress for the nineteenth time Council Directive 67/548/EEC.

The environmental classification was included the harmonized classification by Commission Directive 2004/73/EEC of 29 April 2004 adapting to technical progress for the 29th time Council Directive 67/548/EEC.

RAC general comment
Sodium chlorate is mostly used as an intermediate in the synthesis of chlorates, perchlorates and chlorites, and also in pulp and paper bleaching agent (manufacture of chlorine dioxide). The substance can also be used in the metal finishing industry and for pyrotechnics. Sodium chlorate has an existing entry to CLP regulation as Ox. Sol. 1; H271, Acute Tox. 4*; H302, and Aquatic Chronic 2; H411. The proposal from the dossier submitter (DS) addressed the remove of Aquatic Chronic 2; H411 and modify the acute toxicity classification in Acute Tox. 3; H301.

4 JUSTIFICATION THAT ACTION IS NEEDED AT COMMUNITY LEVEL

Sodium chlorate is classified Aquatic Chronic 2 (H411) in the Annex VI of the CLP regulation. The data that support this classification has been evaluated in this report and considered not valid. The available data that is considered valid for sodium chlorate, as presented in this report, do not support a long-term hazard classification for the environment.

The substance is classified as Acute Tox. 4* for acute oral toxicity. The available data in this report support the classification of Acute Tox. 3 for acute oral toxicity.

[B.] Justification that action is needed at Community level is required.

Reason for a need for action at Community level:

Change in existing entry due to changes in the criteria

Further detail on need of action at Community level

According to the 2nd Adaptation to Technical Progress (ATP) to the CLP Regulation (Commission Regulation (EU) No 286/2011), when adequate chronic toxicity data are available for all three trophic levels, the substance can be classified using the chronic data depending on information on rapid degradation.

Chronic toxicity data of sodium chlorate are available for all three trophic levels (fish, crustacean and algae/aquatic plants). Taking into account that all the chronic toxicity values are above 1 mg/L, no long-term hazard classification is required according to CLP.

As the classification and labelling should properly reflect the hazards of a substance, a change of the classification for the aquatic environment should be considered.

The current Annex VI entry for sodium chlorate includes Aquatic Chronic 2 (H411) in the column "Classification" in Table 3.1. The data used for this classification are not considered valid as evaluated in the REACH registration dossier and explained in section 11 below. The data that is presented in this report and that was the basis for the hazard evaluation in the REACH registration dossier support that the substance does not need to be classified for the aquatic environment.

The current Annex VI entry for sodium chlorate includes Acute Tox. 4* oral as a minimum classification as indicated by the reference * in the column "Classification" in Table 3.1. The data that is presented in this report and that was the basis for the hazard evaluation in the REACH registration dossier supports the classifiction as Acute Tox. 3 for acute oral toxicity.

This CLH report was initially drafted by Nouryon Pulp and Performance Chemicals AB (former AkzoNobel Pulp and Performance Chemicals AB) and submitted via the Swedish Competent Authority.

5 IDENTIFIED USES

Sodium chlorate is mostly used as an intermediate in the synthesis of chlorates, perchlorates and chlorites and also in pulp and paper bleaching agent (manufacture of chlorine dioxide). The substance can also be used in the metal finishing industry and for pyrotechnics.

6 DATA SOURCES

Information on SODIUM CHLORATE was collected from different external sources:

1) Physico-chemical Literature Search (2009.09.07).

STN Databases:

CAS REGISTRY service : The search was performed by CAS number (7775-09-9).

HCAPLUS : The search was performed by CAS number (7775-09-9), and by specific keywords. The result set has been limited by publication year (>1985).

2) Fate/Ecotoxicology Literature Search (2009.09.07). The search was performed by CAS number (7775-09-9), by synonyms (chemical names) and by specific keywords.

STN Databases : HCAPLUS, AQUIRE, BIOSIS, CSNB, RTECS, TOXCENTER, HSDB

A selection of relevant articles was also made via web search engines or directly on publisher websites.

The last literature search is from 2019-05-23. No new information relevant for hazard assessment was found.

REACH dossier: https://echa.europa.eu/registration-dossier/-/registered-dossier/14688/1

European Commission. Draft Assessment Report Chlorate. Prepared by France, January, 2008.

7 PHYSICOCHEMICAL PROPERTIES

Table 75: Summary of physicochemical properties

Property	Value	Reference	Comment (e.g. measured or estimated)
Physical state at 20°C and 101,3 kPa	Crystalline solid, pale yellow	De Ryckel (2006)	
Melting/freezing point	255.0 – 259.4°C at 954 hPa	Paradis (2004)	
Boiling point	Sodium chlorate decomposes when liquefied at 93.6 kPa (>250°C)	Paradis (2003)	

Property	Value	Reference	Comment (e.g. measured or estimated)
Relative density	2.54 g/cm^3 at 20.2°C	Mourgues (2004)	
Vapour pressure	<3.5E^{-07} hPa at 25°C	Tremains (2004)	
Surface tension	72.9 mN/m at 1g/l and at 20°C	Tremains (2003)	The substance is not considered as surface active
Water solubility	696 – 736 g/l at 20°C for pH 4.49 to 8.70	Groult (2004)	
Partition coefficient n-octanol/water	-2.9 at 20°C	Groult (2004)	Weakly soluble in n-octanol
Flash point	Not relevant		
Flammability	Non flammable	De Ryckel (2006)	
Explosive properties	Non explosive	Mak (2004)	
Self-ignition temperature	No relative self-ignition temperature	Mak (2004)	
Oxidising properties	Oxidizing	De Ryckel (2006)	
Granulometry	Determined by sieving: >5000µm: 0.00% 2000-5000µm: 2.00% 1000-2000µm: 25.77% 850-1000µm: 11.06% 600-850µm: 25.71% 500-600µm: 9.11% 400-500µm: 8.93% 200-400µm: 12.20% 150-200µm: 1.5% <150µm: 3.56%	De Ryckel (2006)	
Stability in organic solvents and identity of relevant degradation products	Not applicable		
Dissociation constant	pKa = -1 to -3	Weissenfeld (2004)	
Viscosity	Not applicable		

8 EVALUATION OF PHYSICAL HAZARDS

This part was not evaluated in this dossier and no modification of the classification for physico-chemical properties is proposed.

9 TOXICOKINETICS (ABSORPTION, METABOLISM, DISTRIBUTION AND ELIMINATION)

This part was not evaluated in this dossier.

10 EVALUATION OF HEALTH HAZARDS

Acute oral toxicity

10.1 Acute toxicity - oral route

Table 8: Summary table of animal studies on acute oral toxicity

Method, guideline, deviations if any	**Species, strain, sex, no/group**	**Test substance,**	**Dose levels, duration of exposure**	**Value** **LD_{50}**	**Reference**
EPA OPP 81-1 (Acute Oral Toxicity)	Rat, Sprague-Dawley 5 per sex/group	Sodium chlorate	- range finding study: 300, 600, 1250, 2500 and 5000 mg/kg bw; (one male and one female per dose) - full acute oral limit test 1: 5000 mg/kg bw - full acute oral limit test 2: 2000 mg/kg bw	> 5000 mg/kg bw	Study report , 1991i[1]
OECD Guideline 401 (Acute Oral Toxicity) before 2002	Rat, Charles River CD Range finding: 2 per sex/group, Main study: 8 per sex/group, except in high dose group where 7 females were dosed	Sodium chlorate	- range finding study: 1000, 1500, 5000 mg/kg bw - main study: 1470, 2150, 3160, 4640, 6810 mg/kg bw males and 2150, 3160, 4640, 6810, 10000 mg/kg bw females	Males, 4950 mg/kg in males (95% Confidence limits: 3960 to 6188) Females, 6250 mg/kg in females (confidence limits: 5274 to 7406)	Study report, 1981

Table 9: Summary table of human data on acute oral toxicity

Type of data/report	**Test substance,**	**Lethal dose in mg/kg bw[2]**	**Relevant information about the study (as applicable)**	**Reference**
Review AFSSA (French poison center)[1]	Sodium chlorate	143-286 mg/kg bw (adult)	29 individuals had pathological methemoglobinemia (MetHb ≥ 3%). The smallest doses causing a pathological MetHb (≥ 3%) humans in this study were in the order of 10-20 grams of sodium chlorate orally ingested. 13 (45%) of the 29 individuals did not survive.	AFSSA, 2011
Public literature	Sodium chlorate	No data	Deaths from pesticide poisoning in England and Wales: 1945-1989 Sodium chlorate caused 113 deaths, most of these fatalities occurring between 1965 and	Casey P, Vale JA, 1994

[1] Key study REACH dossier

[2] Estimated intakes per kg bw were calculated with adefault body weight assumption of 70 kg for adults, 10 kg for children and 5 kg for infants.

			1983; only one death has been recorded since 1984.	
Public literature	Sodium chlorate	No data	A chemical industry worker died from sodium chlorate intake, amount unknown	Eysseric H et al, 2000
Public literature	Sodium chlorate	214 mg/kg bw (adult)	Outcome in 14 patients poisoned by sodium chlorate. Mortality was high (64%), and death invariably occurred, irrespective of treatment, when the amount of sodium chlorate ingested exceeded 100 g. In this study, the smallest lethal dose published was 15 g (214 mg of chlorate / kg body weight) and concerned a 46-year-old woman who died at medical care in intensive care. In this same series, another death occurred at a woman (unspecified age) following the intake of a 30 g dose (429 mg / kg chlorate despite treatment with methylene blue, hemodialysis and exsanguino-transfusion.	Helliwell M, Nunn J, 1979
Public literature	Sodium chlorate	No data	Two patients admitted to Halton in 1960 recovered from sodium-chlorate poisoning associated with severe renal failure. Both required hemodialysis (Kolff twin-coil artificial kidney). In one, poisoning occurred accidentally while the patient was using a weed-killer in an atomiser for agricultural purposes; and in the other it was the result of a suicide attempt.	Jackson et al., 1961
Public literature	Sodium chlorate	No death, survided 571 mg/kg bw (adult)	40 g sodium chlorate was taken by error instead of that amount of sodium chloride by a 28-year-old man and he survided.	Klendshoj NC et al., 1962
Public literature	Sodium chlorate	No data	155 cases of which 116 were fatal. Eighteen of these were either suicidal or homicidal.	Witthaus 1911 cited in Klendshoj NC et al., 1962
Public literature	Potassium chlorate	500 mg/kg bw (adult)	Cochran and Smith reported a case of Bright's disease in which potassium chlorate had mistakenly been given instead of potassium chloride. There was evidence that the patient took approximately 35 g over a period of 3 days. Death occurred on the 5th day after the last dose.	Cochran and Smith cited in Klendshoj NC et al., 1962

Public literature	Sodium chlorate	No data	Ansbacher described a rapidly progressing case of a pharmacy student who took the poison in the morning and died the same evening. The symptoms were violent vomiting, deep cyanosis, diarrhea, and the blood was described as dark brown.	Ansbacher cited in Klendshoj NC et al., 1962
Public literature	Sodium chlorate	No data	Gordon and Brown 4 have detailed the case of a woman who had sucked 25 tablets of potassium chlorate daily for from 6 to 10 weeks as a self-prescribed cure for an imaginary malignancy of the tongue. Features of the case were severe hemorrhage, methemoglobinemia, and renal dammage, and death was ultimately ascribed to renaltubular damage due to deposition of pigment.	Gordon and Brown cited in Klendshoj NC et al., 1962
Public literature	Potassium chlorate	No data	Gettler and St. George have cited a fatal case in a 3-year-old boy. The physician prescribed a potassium chlorate gargle over the telephone. The mother misunderstood the directions and gave the child the solution to drink. Death occurred in about 6 hours. The essential findings were 91.9% methemoglobin and acute parenchymatous nephrosis	Gettler and St. George cited in Klendshoj NC et al., 1962
Public literature	Sodium chlorate	No data	The results of the toxicological, macroscopical and microscopical investigations carried out on two cases of suicidal poisoning confirm that death was as a result of chlorate ingestion. No further details are provided.	Oliver JS, Smith H, Watson AA, 1972
Public literature	Sodium chlorate	No data	A homicidal poisoning from sodium chlorate administered intermittently over a period of about 5 weeks.	Jansen H, Zeldenrust J, 1972
Public literature	Potassium chlorate	107 mg/kg bw (adult)	A mentally diseased army officer, aged 33, ate an entire tube of Pebeco Tooth Paste on an empty stomach, corresponding, in the opinion of the author, to 7.5 G of potassium chlorate and died.	Bernstein cited in Klendshoj NC et al., 1962
Public literature	Sodium chlorate	No death, survided 334 mg/kg bw (adult)	A 29 year old man ingested about 20 g of sodium chlorate (230 mg chlorate/kg body weight). He became cyanotic, and	HSDB, 2005, referring to National Research Council, 1987

			his hemoglobin dropped to 11 g/100 mL within 24 hr; methemoglobin and methemoalbumin were detected in his plasma. He was anuric for 14 days, then gradually improved, and he was released from the hospital after 6 wk.	Bloxham CA et al., 1979
Public literature	Sodium chlorate	2143-2857 mg/kg bw (adult)	A case of severe sodium chlorate poisoning was observed within 5 h after suicidal ingestion of 150–200 g of the herbicide. Methaemoglobinaemia was the early symptom of the intoxication.	Steffen C, Seitz R, 1981
Public literature	Sodium chlorate	71-143 mg/kg bw (adult) 133 mg/kg bw (child)	A dose of 5-10 g can prove fatal in adults, as can a dose of 2 g in small children.	Hartley, D. and H. Kidd, 1987
Public literature	Sodium chlorate	No data	A 26 year old man commited suicide, the cause of death was determibed to be methaemoglobinaemia following ingestion of a poison. The toxicological analysis revealed 700 mg of chlorate per 100 ml urine and the stomach contents gave a positive result for chlorate. A 52 year old female commited suicide, toxicological analysis revealed 152,4 mg of chlorate per 100 ml blood and 362,0 mg of chlorate per 100 ml stomach contents.	Cunningham, 1982
Public literature	Sodium chlorate	800 mg/kg bw (LD50 adult female)	The oral LD_{50} in adult women is reported to be 800 mg/kg bw	Lewis, R.J., Sr., 1996
Public literature	Potassium chlorate	No death, survided 600 mg/kg bw (infant)	A 3 month old boy survived ingestion of 3g sodium chlorate.	Vakili M, 1977
Public literature	Potassium chlorate	100 mg/kg bw (adult)	A 76 year old woman died after ingesting a table spoon, about 7 g, of potassium chlorate.	Fukumoto K, Fukumoto H, 1970
Public literature	Potassium chlorate	Unknown	In 1911 reports of 143 cases of poisoning were reported, 116 with a fatal outcome.	Witthaus 1911 cited in Clinical Toxicology, London, 1969
Public literature	Potassium chlorate	Unknown	7 fatal cases were reported between 1911-1940. 6 accidental and 1 suicide.	Cochrane 1940 cited in Clinical Toxicology, London, 1969
Public literature	Sodium chlorate	Unknown	Sodium chlorate poisoning is uncommon. 1 case reported in 1967.	General Register Office, London, 1969
Public literature	Sodium chlorate	No death, survided, 186 mg/kg bw (adult)	55 year old man swallowed 13 g	Davies 1956 cited in Clinical Toxicology, London, 1969

Public literature	Sodium chlorate	No death, survided, 200 mg/kg bw (adult)	Two cases of renal failure due to sodium chlorate poisoning. 67 year old female ingested 14 g of sodium chlorate and survived. In total 12 cases were reported (including the 10 reported by Derot 1948) in this publication and 8 were accidental poisonings.	Jackson 1962 cited in Clinical Toxicology, London, 1969
Public literature	Sodium chlorate	200-429 mg/kg bw (adult)	6 out of 10 cases died, the fatal dose was about 30 g, one person died after 14 g.	Derot 1948 cited in Clinical Toxicology, London, 1969
Public literature	Potassium chlorate	Unknown	5 year old girl swallowed a 2% solution of potassium chlorate, exposed for 7 days and died after 10 days.	Ehnbon 1889 cited in Clinical Toxicology, London, 1969
Public literature	Potassium chlorate	1300 mg/kg bw (adult)	35 year old woman died after consuming tablets of potassium chlorate for 5 days, in total 91 g	Pharm. J. 1950 cited in Clinical Toxicology, London, 1969
Public literature	Potassium chlorate	No death, survided 429-500 mg/kg bw (adult)	Patient received 30-35 g for 3 days.	Cochrane 1940 cited in Clinical Toxicology, London, 1969
Public literature	Potassium chlorate	571 mg/kg bw (adult)	48 year old woman drank 150-200 g of water with 40 g	Balsazs, 1934 cited in Clinical Toxicology, London, 1969
Public literature	Potassium chlorate	107 mg/kg bw (adult)	Man swallowed 7.5 g included in tooth paste.	Bernstein, 1930 cited in Clinical Toxicology, London, 1969
Public literature	Potassium chlorate	267-333 mg/kg bw (child)	8 year old boy was poisoned with an unknown amount, estimated 4-5 g	Wagner, 1934 cited in Clinical Toxicology, London, 1969
Public literature	Sodium chlorate	Unknown	78 year old man was poisoned	Clinical Toxicology, London, 1969
Public literature	Sodium chlorate	333-667 mg/kg bw (child)	17 year old boy with down sydrome	Clinical Toxicology, London, 1969
Public literature	Sodium chlorate	No death, survided, 1071 mg/kg bw (adult) 1286 mg/kg bw (adult)	18 year old man 75 g chlorate in water, survived 78 year old man 90 g chlorate in water, died	O'Grady J, Jarecsni E, 1971
Public literature	Sodium chlorate	Unknown	57 year old man, 43 year old man and a 19 year old man committed suicide by eating chlorate	Timperman J, Maes R, 1966
Public literature	Sodium chlorate	No death, survived, 714 mg/kg bw (adult)	23 year old woman consumed about 50 g and survived	Yoshida Y et al., 1977
Public literature	Sodium chlorate	Unknown	13 year old boy tasted sodium chlorate by dipping his finger in the crystals and licking it. He became ill but survived.	Stavrou et al., 1978
Public literature	Sodium chlorate	No death, survived, 571 mg/kg bw (adult)	22 year old male ingested 40 g and survived. 57 year old male ingested an unknown amount and survived.	Granier P et al., 1985

a) unknown means that the original article could not be retrieved

Table 10: Summary table of other studies available for acute oral toxicity

Method, guideline, deviations if any	**Species, strain, sex, no/group**	**Test substance,**	**Dose levels, duration of exposure**	**Value** LD_{50}	**Reference**
Not specified, , acute study	Dog, collie and boxer, 5 in total, sex not specified	Sodium chlorate	one dog: 0.5 g/kg bw two dogs: 1 g/kg bw one dog: 2 g/kg bw	One of the the 1 g/kg bw dogs died (boxer) and the 2 g/kg bw dog died (collie)	Sheahan, 1971
Not specified, , acute study	Not specified	Sodium chlorate	Not specified	1200 - 7000 mg/kg bw	Ben-Dyke, 1970
Not specified, acute study	Rat , no further details specified	Sodium chlorate	Not specified	7-8 g/kg bw	Frank, 1948 in Smith et al, 2012
Not specified, acute study	Rat , no f urther details specified	Sodium chlorate	Not specified	1200 mg/kg bw	Edson, 1960 in Smith et al, 2012

10.1.1 Short summary and overall relevance of the provided information on acute oral toxicity

Animal studies

The key animal study (Study report, 1991i) was performed in accordance with EPA Acute Toxicity Guideline, OPP 81-1 (equivalent to OECD Guideline 401,Acute Oral Toxicity) on sodium chlorate in compliance with GLP. The test material, Sodium Chlorate Crystal, was evaluated for its acute oral toxicity potential in 30 Sprague Dawley rats. Ten animals were used in a dose range finding study (dose levels: 5, 2.5, 1.25, 0.6 and 0.3 g/kg bw). Thereafter Sodium Chlorate was administered as gavage doses (5.0 g/kg and second (2.0 g/kg) in a first limit test. No mortality occurred in animals dosed at 2.0 g/kg and 1 animal died at dose level 5.0 g/kg. Clinical signs of toxicity at 5.0 g/kg included hunched posture and reduced feces, which were no longer evident on Day 3. At 2.0 g/kg only hunched posture was observed at 2 -4 hours post dosing in one male. There was no significant effect on body weight gain in animals surviving to termination. Necropsy findings at 5.0 g/kg showed green discoloration of the intestines, a light green fluid in the stomach, pink liquid in the abdominal cavity and dark red lung discoloration. At 2.0 g/kg only slight to moderate redness in the lungs of all animals was observed. Conclusions: The acute oral LD50 of Sodium Chlorate Crystal was determined to be greater than 5000 mg/kg bw.

A valid supporting study (Study report, 1981) was equivalent to OECD Guideline 401 (Acute Oral Toxicity). The study was not designed and performed according to GLP. The test material, Sodium Chlorate, was evaluated for its acute oral toxicity potential in Charles River CD rats. Twelve animals were used in a range finding study (dose levels: 5000, 1500 and 1000 mg/kg bw). During the main study Sodium Chlorate was administered as gavage doses at levels of 10000, 6810, 4640, 3160, 2150 and 1470 mg/kg to 8 males and 8 females per dose group, with the exception of 10000 mg/kg dose in which 7 females were dosed and 1470 mg/kg dose in which 8 males were dosed. Mortality occurred in 10 males dosed at the 4640 mg/kg and 6810 mg/kg level. In total 12 females died at the 6810 mg/kg level and the 10000 mg/kg level. Clinical signs of toxicity included ataxia at dose levels greater than 2150 (males) and 4640 (females) mg/kg bw. At dose levels greater than 3160 (male) and 2150 (female) mg/kg bw signs of decreased motor activity, yellow semi-solid discharge from the anus and yellow wet fur around the inguinal and perianal regions were observed. The animals that died during the study showed discoloration of the thoracic and abdominal organs. Necropsy findings among

survivors consisted of one male rat at 4640 mg/kg bw which exhibited a slightly mottled right kidney. There was a small gain in body weight in animals surviving to termination.
Conclusions: The acute oral LD50's of Sodium Chlorate were determined to be ca. 4950 mg/kg in males and ca. 6250 mg/kg in females.

A review from 2012 (Smith et al., 2012) shows that single or short duration (<3 d) exposures to oral chlorate at concentrations < 150 mg/kg bw have not produced acute toxicity or clinical signs (labored breathing, methemoglobinemia) in cattle, chicken, horse, rabbit, sheep, or swine.

The study of Sheahan (1971) is included as supporting evidence but is of limited reliability due to study design and poor reporting. The additional studies in table 10 are of very limited reliability due to lack of information on the studies and are only included for completeness and are thus not considered in the assessment of acute oral toxicity for sodium chlorate.

In conclusion, animal studies (rat and dog) with sodium chlorate show a low acute toxicity after oral (LD50 = 4950-6250 mg/kg bw) exposure (Study report, 1991i, Study report, 1981, Sheahan 1971).

In the records on the decision on classification of sodium chlorate from TC C&L, 1989 a LD50 of 1200 mg/kg bw in rat was identified. However, the study report is not available to the dossier submitter. The EFSA scientific opinion (Risks for public health related to the presence of chlorate in food, EFSA 2015) also mention that “other publications” reported oral LD50 for sodium chlorate to be 1200 mg/kg b.w. (equivalent to 936 mg chlorate/kg bw) in rats (Lewis, 1996; HSDB, 2003; as cited in EFSA scientific opinion 2015) and the oral LD50 for potassium chlorate to be 1 870 mg/kg bw (equivalent to 1272 mg chlorate/kg bw) in rats (RTECS, 1994; as cited in EFSA scientific opinion 2015). In the Registry of Toxic Effects of Chemical Substances from NIOSH the oral LD50 in rat was 1870 mg/kg. None of these rat studies are available to the dossier submitter to be able to assess quality and reliability. These studies would, if considered as sufficiently robust, justify classification in category 4.

Human data

Numerous human case studies are reported for sodium chlorate. In table 9, several case reports cited originally in the dossier for OECD cooperative Chemicals Assessment Programme, High production volume (HPV) chemicals and included in the REACH dossier are listed. Most are only abstract and a robust summary is therefore not provided in annex I of this report.

The human case studies are described accidental poisoning (Clinical toxicology, 1969; Casey P, Vale JA, 1994; Eysseric H et al, 2000; Fukumoto K, Fukumoto H, 1970; General Register Office, London, 1969; Helliwell M, Nunn J, 1979; Jackson RC et al, 1961; Vakili M, 1977; Stavrou et al. 1978), suicide (Bloxham CA et al., 1979; Granier P et al., 1985; General Register Office, London, 1969; Jackson RC et al, 1961; Klendshoj NC et al., 1962;O’Grady J, Jarecsni E, 1971; Oliver JS, Smith H, Watson AA, 1972; Steffen C, Seitz R., 1981; Timperman J, Maes R, 1966; Yoshida Y et al., 1977) and homicide attempts (Jansen H, Zeldenrust J, 1972).

In summary, the studies report that doses of 5 to 10 grams (71-143 mg/kg bw[3]) can be fatal in adults, and doses of 2 grams (0.2 g/kg bw[3]) in children. But also multiple cases are described surviving intakes ranging from 40 g (571 mg/kg bw[3]) to even 150-200 grams (2.1-2.9 g/kg bw[3]). This is likely related to the possibility of dialysis treatment in case of renal failure after 1960s.. In many cases, the lethal dose in human are above 20 g (285 mg/kg bw[3]) (Helliwell and Nunn, 1979). The oral LD50 in adult women is reported to be 800 mg/kg (Lewis, 1996). The SIDS Initial Assessment Report on Sodium chlorate summarises that lethality is reported from after 4 hours up to 34 days, with an

[3] Estimated intakes per kg bw were calculated with adefault body weight assumption of 70 kg for adults, 10 kg for children and 5 kg for infants.

average of about 4 days, and that the acute toxicity of chlorate is mediated by methemoglobin. In the NTP technical report on the toxicology and carcinogenesis studies of sodium chlorate from 2005 the acute toxicity in humans has been summarised and it was stated that death has been most frequently associated with doses of 20 g or greater, although recovery has been noted in patients who ingested as much as 200 g. Moreover, the report describes that *chlorate toxicity after ingestion in humans can be characterized primarily by gastrointestinal irritation, massive intravascular hemolysis, disseminated intravascular coagulation, cyanosis, and renal failure. Gastrointestinal irritation appears to be the result of a direct effect of the chlorate ion on the gastrointestinal mucosa. The intravascular hemolysis occurs subsequent to the formation of methemoglobin in exposed erythrocytes, eventually resulting in cyanosis. In addition, chlorate exerts a direct toxic effect on the proximal tubule of the kidney, causing necrosis and preventing the formation of urine and subsequent elimination of chlorate from the blood stream, thus prolonging exposure of the erythrocytes.*

Nephrotoxicity also seems mediated by methaemoglobin catalysis. Methaemoglobin thus autocatalytically increases methaemoglobin formation and destruction of the erythrocyte, which is shown in in vitro experiments (Steffen C, Wetzel, 1993).

In an evaluation of sodium chlorate by the French poison control center (2011) a retrospective study was conducted over a period ranging from 1999 to 2009 to identify human cases of exposure to chlorate preparations reported to poison control and toxicovigilance centers. 29 individuals had pathological methemoglobinemia (MetHb ≥ 3%). The lowest doses at which methemoglobenemia was observed were in the range of 10-20 grams of sodium chlorate taken by ingestion. 13 (45%) of the 29 individuals did not survive. The cause of death related to the hematological and renal effects of chlorates as described above and / or the complications of reanimation. In this study, the lowest estimated oral lethal doses were 8.8 g (125 mg/kg bw[4]), 17.5 g (250 mg/kg bw[4]), and 28.8 g (410 mg/kg bw[4]), of sodium chlorate which are in same range as previously published lowest lethal doses in humans.

Records from the TC C&L from 1989 on the classification of sodium chlorate indicates lowest human lethal doses of 50 mg/kg and 214 mg/kg in adults and a LD50 for children at 185 mg/kg. We could not track the references but the lowest lethal dose 50 mg/kg may have been cited from Gosselin, Clinical Toxicology of Commercial Products (CTCP) 4th ed, 1976 where oral lethal dose is reported to be 50-500 mg/kg for a 70 kg person. The lowest lethal dose 214 mg/kg may have been cited from Helliwell and Nunn, 1979 where the lowest letal dose was 15 g = 214 mg/kg bw for a 70 kg person.

In the scientific opinion by EFSA (2015), a report from NRC (1980) is cited where lethal doses in adults were estimated to be 20 to 35 g for sodium chlorate and 5 to 30 g for potassium chlorate. Consequently, the oral lethal dose for these salts were 71 to 500 mg/kg (based on adult bw 70 kg).

Summary

Animal studies with sodium chlorate show a low acute toxicity (LD50 > 5000 mg/kg bw) after oral exposure. In contrast, available human data show lethality in humans at lower concentrations of chlorate and the acute toxicity of chlorate has been associated with methemoglobin. There are marked species differences in susceptibility to form methemoglobin where humans appears as more severly affected than rodent species.

10.1.2 Comparison with the CLP criteria

Based on available data from one study of sodium chlorate in rat, the LD50 was reported to be > 5000 mg/kg bw. This does not met the criteria of classification in Acute Tox. 4 for oral administration.

[4] Estimated intakes per kg bw were calculated with adefault body weight assumption of 70 kg for adults, 10 kg for children and 5 kg for infants.

However, information from human poisoning incident reports demonstrate lethal effects of sodium- and potassium chlorate at concentration ranges that warrant classification.

The information from the publications summarized should be viewed with care for deriving an exact acute toxicity estimate for sodium chlorate since a lethal dose which is fatal to 50% (LD50) of the exposed group cannot be derived. Due to vomiting occurring, sometimes rapidly after ingestion, the absorbed quantity is often uncertain. Therefore, variability occurs in the doses causing lethality. However, the data do show that in mg/kg bw humans are more sensitive to acute sodium- and potassium chlorate toxicity when compared to animals.

According to the Guidance on the Application of the CLP Criteria (v.5, July 2017) *"The minimum dose or concentration or range shown or expected to cause mortality after a single human exposure can be used to derive the human ATE directly, without any adjustments or uncertainty factors"*.

The lowest lethal doses or ranges reported in this CLH-proposal are the following:

- 71-142 mg/kg bw in adults (based on assumption of default body weight 70 kg) and 133 mg/kg bw in children (Hartley and Kidd, 1987)
- 100 mg/kg bw in a 76 year old woman (based on assumption of default body weight as 70 kg) (Fukomoto and Fukomoto, 1970)
- 107 mg/kg bw in an adult man (based on assumption of default body weight as 70 kg) (Bernstein cited in Klendshoj 1962)
- 125 mg/kg bw in an 43 year old male (based on assumption of default body weight as 70 kg) (AFSSA report 2011).
- 214 mg/kg bw in an 46 year old woman (based on assumption of default body weight as 70 kg) (Helliwell and Nunn, 1979)

Thus, based on a number of human case reports indicating lowest lethal doses < 300 mg/kg bw the dossier submitter consider that a category 3 classification rather than the current category 4 (minimum classification) is justified. In line with CLP guidance (to use the minimum dose or range shown or expected to cause mortality) for deriving a human ATE and considering that the available human data is quite incoherent we propose to use the converted Acute Toxicity point Estimate (cATpE), which is 100 mg/kg bw for category 3, to set the ATE.

The alternative view of the Registrant is as follows: Gathered from the available human data that the lowest lethal doses were reported to be 5 to 10 grams but that most frequently the lethal doses were above 20 g (Helliwell and Nunn, 1979) the relevant starting point for deriving the ATE is above 286 mg/kg bw. In the light of the quality of the data and related uncertainties the registrant believes there is no logical choice to use the minimum dose as the basis for the ATE, and suggest maintaining the Acute Tox. 4 classification.

The reasoning behind the TC C&L classification (Xn; R22) is not available to the dossier submitter. Therefore we do not know if the human data or the rat LD0 of 1200 was used to compare against the guidance values under DSD for Xn; R22 (200 – 2000 mg/kg bw) which later has been translated into Acute Tox. 4 (oral) under CLP.

10.1.3 Conclusion on classification and labelling for acute oral toxicity

Currently sodium chlorate has a harmonised classification as Acute Tox. 4* (H302) for the oral route of exposure. Based on the weight of the evidence of available human data and using expert judgement the dossier submitter proposes that classification of sodium chlorate in Acute Tox. 3, H301 is warranted with a cATpE of 100 mg/kg bw. A more stringent classification is thus proposed.

RAC evaluation of acute toxicity

ACUTE TOXICITY-ORAL ROUTE

Summary of the Dossier Submitter's proposal

Animal studies on acute oral toxicity (cf. Table 8 of the CLH report):

Species	LD_{50} (mg/kg bw)	Dosing (mg/kg bw)/Test substance	Results (mortality)	Reliability (DS)	Study	Remarks
Sprague-Dawley rat, 5 animals/sex/dose	>5000 mg/kg bw	2000/ sodium chlorate 5000/ sodium chlorate	2000: 0(M)/0(F)/5 (M)/5(F) 5000: 0(M)/1(F)/5(M)/5(F)	1	1991	GLP study according to EPA OPP 81-1 (Acute Oral Toxicity)
CD rat, 2 animals/sex/dose – range finding study and 8 animals/sex/dose, except 10000 g where 8 males and 7 females were tested – main study	4950 (male) 6250 (female)	**Range study:** 1000;1500; 5000/ sodium chlorate **Main study**: 1470; 2150; 3160; 4640; 6810/ sodium chlorate (male) 2150; 3160; 4640; 6810; 10000/ sodium chlorate (female)	**Range study:** **Male**: 5000: 2/2 1500: 0/2 1000: 0/2 **Female**: 5000: 0/2 1500: 0/2 1000: 0/2 **Main study**: **Male**: 6810: 7/8 4640: 3/8 3160: 0/8 2150: 0/8 1470: 0/8 **Female**: 10000: 7/7 6810: 5/8 4640: 0/8 3160: 0/8 2150: 0/8	2	1981	OECD TG 401 (Acute Oral Toxicity) before 2002; No information on test substance purity, No GLP
Collie and boxer dog/ 1 or 2 animals/dose, sex not specify	No LD_{50} obtained	500; 1000; 2000; (gavage); 5000 (by slow i.v. injection)	500: 0/1 1000: 1(boxer)/2 2000: 1(collie)/1	3	1971	No GLP or according to a standard method
Not specified	1200-7000	Not specified	Not specified	4	1970	No GLP, no guideline specified
Rat, no further detail	7000-8000	Not specified	Not specified	4	1948	No specified
Rat, no further detail	1200	Not specified	Not specified	4	1960	No specified

In the records on the decision on classification of sodium chlorate from Technical Committee on Classification and Labelling (TC) C&L, 1989 a LD_{50} of 1200 mg/kg bw in rat was identified. However, the study report is not available to the dossier submitter. The 2015 EFSA scientific opinion (Risks for public health related to the presence of chlorate in food) also mention that "other publications" reported oral LD_{50} for sodium chlorate to be 1200 mg/kg bw (equivalent to 936 mg chlorate/kg bw) in rats (Lewis 1996, HSDB 2003, as cited in EFSA scientific opinion 2015) and the oral LD_{50} for potassium chlorate to be 1 870 mg/kg bw (equivalent to 1272 mg chlorate/kg bw) in rats (RTECS 1994 as cited in

EFSA scientific opinion 2015). In the Registry of Toxic Effects of Chemical Substances from NIOSH the oral LD_{50} in rat was 1870 mg/kg. None of these rat studies are available to the DS to be able to assess quality and reliability.

Available human data on acute oral toxicity (cf. Table 9 of the CLH report for the full reference):

Type of data/report	**Test substance**	**Lethal dose in mg/kg bw[1]**	**Relevant information about the study (as applicable)**	**Limitation**	**Year of the study**
Review AFSSA (French poison center)[1]	Sodium chlorate	143-286 mg/kg bw (adult)	29 individuals had pathological methemoglobinemia (MetHb ⩾ 3%). The smallest doses causing a pathological MetHb (⩾ 3%) humans in this study were in the order of 10-20 grams of sodium chlorate orally ingested. 13 (45%) of the 29 individuals did not survive.	No data regarding the other comorbidities and pathologies of the individuals that can influence the toxicity of sodium chlorate	2011
Public literature/ Case report-accidental poisoning	Sodium chlorate	214 mg/kg bw (adult)	Outcome in 14 patients poisoned by sodium chlorate. Mortality was high (64%), and death invariably occurred, irrespective of treatment, when the amount of sodium chlorate ingested exceeded 100 g. In this study, the smallest lethal dose published was 15 g (214 mg of chlorate/kg body weight) and concerned a 46-year-old woman who died at medical care in intensive care. In this same series, another death occurred at a woman (unspecified age) following the intake of a 30 g dose (429 mg / kg chlorate despite treatment with methylene blue, hemodialysis and exsanguino-transfusion.	No data regarding the other comorbidities and pathologies of the individuals that can influence the toxicity of sodium chlorate for the 2 cases where the doses were lower than the average dose that produces high mortality (>100 g that is equivalent to 1428 mg/kg bw)	1979
Public literature/ Case report –	Sodium chlorate	No death, survived 571	40 g sodium chlorate was taken by error instead of that amount of sodium chloride by a	No data regarding the other comorbidities and pathologies of the individuals that can	1962

accidental poisoning		mg/kg bw (adult)	28-year-old man and he survived.	influence the toxicity of sodium chlorate	
Public literature/ Case reports - accidental poisoning	Potassium chlorate	500 mg/kg bw (adult)	Cochran and Smith reported a case of Bright's disease in which potassium chlorate had mistakenly been given instead of potassium chloride. There was evidence that the patient took approximately 35 g over a period of 3 days. Death occurred on the 5th day after the last dose.	Bright's disease or glomerulonephritis can potentiate the direct toxic effect of chlorate on the proximal tubule of the kidney, preventing the elimination of the chlorate and prolonging the exposure of the erythrocytes increasing the toxicity compared to a healthy adult	1940
Public literature/ Case report – suicide attempt	Potassium chlorate	107 mg/kg bw (adult)	A mentally diseased army officer, aged 33, ate an entire tube of Pebeco Tooth Paste on an empty stomach, corresponding, in the opinion of the author, to 7.5 G of potassium chlorate and died.	No data regarding the other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate and if other substance was also involved taking into account that it was a mentally diseased individual.	1930
Public literature/ Case report – suicide attempt	Sodium chlorate	No death, survided 334 mg/kg bw (adult)	A 29 year old man ingested about 20 g of sodium chlorate (230 mg chlorate/kg body weight). He became cyanotic, and his hemoglobin dropped to 11 g/100 mL within 24 hr; methemoglobin and methemoalbumin were detected in his plasma. He was anuric for 14 days, then gradually improved, and he was released from the hospital after 6 wk.	No data regarding the other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1987; 1979
Public literature/ Case report – suicide attempt	Sodium chlorate	2143-2857 mg/kg bw (adult)	A case of severe sodium chlorate poisoning was observed within 5 h after suicidal ingestion of 150– 200 g of the herbicide. Methaemoglobinaemia was the early symptom of the intoxication.	No data regarding the other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1981

Public literature/ Case report	Sodium chlorate	71-143 mg/kg bw (adult) 133 mg/kg bw (child)	A dose of 5-10 g can prove fatal in adults, as can a dose of 2 g in small children.	No data regarding the other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1987
Public literature/ Case report – poisoning cases	Sodium chlorate	800 mg/kg bw (LD_{50} adult female)	The oral LD_{50} in adult women is reported to be 800 mg/kg bw	No data regarding the study and other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1996
Public literature/ Case report-poisoning cases	Potassium chlorate	No death, survided 600 mg/kg bw (infant)	A 3-month-old boy survived the ingestion of 3g sodium chlorate.	No more data regarding the study	1977
Public literature/ Case report – accidental poisoning	Potassium chlorate	100 mg/kg bw (adult)	A 76-year-old woman died after ingesting a tablespoon, about 7 g, of potassium chlorate.	No data regarding the other comorbidities/pathologies of the individual that can influence the toxicity of potassium chlorate	1970
Public literature/ Case reports-poisoning or suicide attempts	Sodium chlorate	No death, survided, 186 mg/kg bw (adult)	55 year old man swallowed 13 g	No data regarding other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1956
Public literature/ Case reports-poisoning or suicide attempts	Sodium chlorate	No death, survided, 200 mg/kg bw (adult)	Two cases of renal failure due to sodium chlorate poisoning. 67 year old female ingested 14 g of sodium chlorate and survived. In total 12 cases were reported (including the 10 reported by Derot 1948) in this publication and 8 were accidental poisonings.	No data regarding other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1962
Public literature/ Case reports-poisoning or suicide attempts	Sodium chlorate	200-429 mg/kg bw (adult)	6 out of 10 cases died, the fatal dose was about 30 g, one person died after 14 g.	No data regarding other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1948
Public literature/ Case report –	Potassium chlorate	1300 mg/kg bw (adult)	35 year old woman died after consuming tablets of potassium	No data regarding other comorbidities/pathologies of the individual that can	1950

suicide attempt			chlorate for 5 days, in total 91 g	influence the toxicity of sodium chlorate	
Public literature/ Case report – accidental poisoning	Potassium chlorate	No death, survided 429-500 mg/kg bw (adult)	Patient received 30-35 g for 3 days.	No data regarding other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1940
Public literature/ Case report - suicide attempt	Potassium chlorate	571 mg/kg bw (adult)	48 year old woman drank 150-200 g of water with 40 g	No data regarding other comorbidities/pathologies of the individual that can influence the toxicity of potassium chlorate	1934
Public literature/ Case report - suicide attempt	Potassium chlorate	107 mg/kg bw (adult)	Man swallowed 7.5 g included in tooth paste.	No data regarding other comorbidities/pathologies of the individual that can influence the toxicity of potassium chlorate	1930
Public literature/ Case report - poisoning	Potassium chlorate	267-333 mg/kg bw (child)	8 year old boy was poisoned with an unknown amount, estimated 4-5 g	No data regarding other comorbidities/pathologies of the individual that can influence the toxicity of potassium chlorate	1934
Public literature/ Case report - poisoning	Sodium chlorate	333-667 mg/kg bw (child)	17 year old boy with down sydrome	No data regarding the other comorbidities/pathologies of the individual that can influence the toxicity of potassium chlorate	1969
Public literature/ Case report - poisoning	Sodium chlorate	No death, survided, 1071 mg/kg bw (adult) 1286 mg/kg bw (adult)	18 year old man 75 g chlorate in water, survived 78 year old man 90 g chlorate in water, died	No data regarding the other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1971
Public literature/ Case report – suicide attempt	Sodium chlorate	No death, survived, 714 mg/kg bw (adult)	23 year old woman consumed about 50 g and survived	No data regarding the other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1977
Public literature/ Case report – suicide attempt	Sodium chlorate	No death, survived, 571 mg/kg bw (adult)	22-year-old male ingested 40 g and survived. A 57-year-old male ingested an unknown amount and survived.	No data regarding the dose/or other comorbidities/pathologies of the individual that can influence the toxicity of sodium chlorate	1985

[1]Estimated intakes per kg bw were calculated with a default body weight assumption of 70 kg for adults, 10 kg for children and 5 kg for infants. Unknown means that the original article could not be retrieved.

There is a key rat study (1991) performed in accordance to EPA Acute Toxicity Guideline, OPP 81-1 (equivalent to OECD Test Guideline (TG) 401) on sodium chlorate in compliance with GLP that showed that LD_{50} of Sodium Chlorate Crystal is > 5000 mg/kg bw and supported by other two animal study one in rats (1981) equivalent with OECD TG 401, not GLP, no information on test substance purity that showed a LD_{50} of 4950 mg/kg bw in males and 6250 mg/kg bw in females and one dog study (1971) with limited reliability used only as supporting evidence. These studies showed that sodium chlorate show a low acute toxicity LD_{50} > 5000 mg/kg bw that does not met the criteria of classification in Acute Tox. 4 for oral administration. The animal studies that have been used in the TC C&L from 1989 for classification according to which a LD_{50} of 1200 mg/kg bw rat was identified are not available to the DS. The studies reported in EFSA scientific opinion that state a LD_{50} for sodium chlorate of 1200 mg/kg bw in rats (Lewis 1996, HSDB 2003, as cited in EFSA scientific opinion 2015) are not available for assessment.

Several human case studies are describing accidental poisoning or suicide/homicide attempts with several limitations due to lack of robust summary that reported that doses of 5 to 10 grams (71-143 mg/kg bw) can be fatal in adults, and doses of 2 grams (0.2 g/kg bw) in children. But also multiple cases are described as surviving intakes ranging from 40 g (571 mg/kg bw3) to even 150-200 grams (2.1-2.9 g/kg bw). In many cases, the lethal dose in human is above 20 g (285 mg/kg bw) (Helliwell and Nunn 1979). The oral LD_{50} in adult women is reported to be 800 mg/kg (Lewis 1996).

Chlorate toxicity after ingestion in humans can be characterized primarily by gastrointestinal irritation, massive intravascular hemolysis, disseminated intravascular coagulation, cyanosis, and renal failure. Gastrointestinal irritation appears to be the result of a direct effect of the chlorate ion on the gastrointestinal mucosa. Intravascular hemolysis occurs after the formation of methemoglobin (MetHb) in exposed erythrocytes, eventually resulting in cyanosis. Besides, chlorate exerts a direct toxic effect on the proximal tubule of the kidney, causing necrosis and preventing the formation of urine and subsequent elimination of chlorate from the bloodstream, thus prolonging the exposure of the erythrocytes. Nephrotoxicity also seems mediated by MetHb catalysis. MetHb thus autocatalytically increases (MetHb)formation and destruction of the erythrocyte, which is shown in in vitro experiments. There are marked species differences in susceptibility to form methemoglobin where humans appear as more severely affected than rodent species.

The human poisoning incident reports demonstrate the lethal effect of sodium- and potassium chlorate at concentration ranges that warrant classification.
The lowest lethal doses or ranges reported in this CLH-proposal are the following:

- 71-142 mg/kg bw in adults (based on the assumption of default body weight 70 kg) and 133 mg/kg bw in children (Hartley and Kidd 1987)
- 100 mg/kg bw in a 76-year-old woman (based on the assumption of default bodyweight as 70 kg) (Fukomoto and Fukomoto 1970)
- 107 mg/kg bw in an adult man (based on the assumption of default bodyweight as 70 kg) (Bernstein cited in Klendshoj 1962)
- 125 mg/kg bw in a 43-year-old male (based on the assumption of default bodyweight as 70 kg) (AFSSA report 2011).
- 214 mg/kg bw in a 46-year-old woman (based on the assumption of default bodyweight as 70 kg) (Helliwell and Nunn 1979)

Thus, based on several human case reports indicating the lowest lethal doses < 300 mg/kg bw the DS considers that a category 3 classification is justified rather than the current category 4 (minimum classification). In line with CLP guidance (to use the minimum dose or range shown or expected to cause mortality) for deriving a human ATE and considering that the available human data is quite incoherent, the DS proposes to use the converted Acute Toxicity point Estimate (cATpE), which is 100 mg/kg bw for category 3, to set the ATE.

Comments received during consultation

Twelve comments were received: 3 from the Member State Competent Authorities (MSCA) and 9 from the industry (IND).

3 MSCA agreed with the proposal as Acute Tox. 3, H301 with an ATE of 100 mg/kg bw.

4 IND members comments pointed out that the industrial use of sodium chlorate is mainly to produce ClO_2, which is already classified as Acute Tox. 2, and that the manufacturing process of sodium chlorate is made in such a way that exposure of sodium chlorate to workers is very low. Also, sodium chlorate use as a herbicide was banned in Europe in 2008. Because $NaClO_3$ reacts strongly with organic materials, contact with workers is controlled; accidental oral poisoning will not happen even in case of loss of containment. Fatalities via the oral route involving workers are not reported. Also, sodium chlorate use as a herbicide was banned in Europe in 2008 and therefore neither consumers nor professional users have access to this product. They suggest maintaining the Acute Tox. 4 classifications for sodium chlorate.

5 IND commented that the Guidance on the Application of the CLP Criteria (v.5, July 2017) states that "the minimum dose or concentration or range is shown or expected to cause mortality after a single human exposure can be used to derive the human ATE directly, without any adjustments or uncertainty factors". The proposal for Acute Tox 3 classification is based on human data from suicide or accidental poisoning incidents, without a systematic gathering of information; controlled studies on animals lead to quite higher ATE values. As only well trained and protected workers are expected to be in contact with sodium chlorate, these poisoning incidents are not expected to happen anymore. Therefore, IND comments consider that the classification as Acute Tox. 3 is not well-founded and do not support it.

2 IND comments from the above 5 refer also to the 83 g/kg bw used as the basis for ATE derivation. The 2 IND comments did not agree with the CLH proposal and consider 332 mg/kg bw is more relevant as lethal doses in humans are above 20 g (332 mg/kg bw) (Helliwell and Nunn 1979), and also as the death has been more frequently associated with doses of 20 g (333 mg/kg bw) or greater, although recovery has been noted in patients who ingested as much as 200 g (3333 mg/kg bw) (NTP 2005).

The DS responded to the 4 IND comments by stating that the lack of reports for adverse effects of workers to $NACIO_3$ is not sufficient evidence to exclude potential adverse effects of $NaClO_3$ and does not negate positive results from animal studies or human case studies. Moreover, they wanted to emphasize that exposure is not taken into consideration in the classification, since classification is based on the intrinsic hazardous properties of the substance.

The DS responded to the 5 IND comments regarding the CLP criteria for classification and the 2 that commented regarding the ATE value: that rats appear to have lower sensitivity

to MetHb formation compared to humans and rat data are therefore not considered to be adequate for acute toxicity classification. Consequently, the assessment of acute toxicity needs to be based on available human data. They agree that the evaluation of human data may be difficult due to various limitations, such as uncertainties relating to exposure assessment. However, according to the CLP guidance 3.1.2.3.1, "The minimum dose or concentration or range shown or expected to cause mortality after a single human exposure can be used to derive the human ATE directly, without any adjustments or uncertainty factors". Following the CLP guidance 3.1.2.3.1 and the guidance example in 3.1.5.1.1 an ATE derived from the available data needs to be set despite the various limitations of human data. There are several cases available in the CLH proposal with human lethal doses (lowest lethal doses are summarised on page 17-18 in the CLH report, ranging from 71 mg/kg bw to 214 mg/kg bw) that support category 3 rather than category 4. An ATE needs to be set to protect also the most sensitive groups in the population. Therefore it may be considered justified to select the lowest dose or dose ranges. The DS finds that, by using a Weight of evidence approach and expert judgement, it is justified to use the converted Acute Toxicity point Estimate (cATpE), which is 100 mg/kg bw for category 3.

Assessment and comparison with the classification criteria

According to the CLP guidance, the preferred test species for evaluation of acute toxicity by oral routes is the rat. When experimental data for acute toxicity are available in several animal species, scientific judgement shall be used in selecting the most appropriate LD_{50} values from among valid, well-performed tests.

There is a 1991 GLP study (regarded by the US EPA as a key animal study) with reliability 1 based on the DS assessment, a valid GLP supporting study from 1981, a non-GLP study with reliability 2 based on the DS assessment, and a non-GLP study with low reliability based on the DS assessment that supports no classification as the LD_{50} = 4950-6250 mg/kg bw. There are several studies with low reliability due to lack of data that suggested the LD_{50} = 1200 mg/kg bw in rats from 1960 that the DS does not have access to, and that ECHA was unable to find, that supported the previous classification as Acute Tox. 4.

There are several human case studies of accidental poisoning or suicidal attempts evaluated by the DS, mainly because humans are more sensitive to methemoglobinemia produced by sodium chlorate compared to rodents. The main mechanism of chlorate toxicity after ingestion in humans can be characterized primarily by gastrointestinal irritation, massive intravascular hemolysis, disseminated intravascular coagulation, cyanosis, and renal failure. Gastrointestinal irritation appears to be the result of a direct effect of the chlorate ion on the gastrointestinal mucosa. The intravascular hemolysis occurs subsequent to the formation of methemoglobin in exposed erythrocytes, eventually resulting in cyanosis. In addition, chlorate exerts a direct toxic effect on the proximal tubule of the kidney, causing necrosis and preventing the formation of urine and subsequent elimination of chlorate from the bloodstream, thus prolonging the exposure of the erythrocytes. Nephrotoxicity also seems mediated by MetHb catalysis. MetHb thus autocatalytically increases MetHb formation and destruction of the erythrocyte, which is shown in in vitro experiments (Steffen, Wetzel 1993).

The lowest lethal doses or ranges reported in the CLH-proposal with in-depth analyses by RAC are the following:

- 71-142 mg/kg bw in adults (based on the assumption of default body weight 70 kg) and 133 mg/kg bw in children, no data available regarding the treatment applied or other comorbidities (Hartley and Kidd 1987)
- 100 mg/kg bw in a 76 year old woman (based on the assumption of default body weight as 70 kg), no data regarding the treatment applied or other comorbidities (Fukomoto and Fukomoto 1970)
- 107 mg/kg bw in a 33 year-old man (based on the assumption of default body weight as 70 kg) that ate an entire tube of Pebeco Tooth Paste that contain the equivalent of 7.5 g of potassium chlorate on an empty stomach. No details regarding the treatment applied could be found (Bernstein cited in Klendshoj 1962)
- 125 mg/kg bw in a case of a 43 years-old-man that volunteer ingested an equivalent of 8.8 g sodium chlorate contained in 5 mL powder based on self-report. He denied exposure to other chemicals. He presented to the hospital with multiple clinical complications as renal insufficiency, hemolysis, deglobulinization, thrombocytopenia and respiratory distress requiring intubation, resulting in death from shock before 48 hours. The treatment applied was methylene blue and vitamin C (AFSSA report 2011). Interesting is that in that case series the patients that survived doses 4456 mg/kg bw, 2500 mg/kg bw, 1683 mg/kg bw or 933 mg/kg bw underwent treatment by hemodialysis (AFSSA 2011).
- 214 mg/kg bw in a case of a 46-year-old woman that accidentally ingested 15 g of sodium chlorate equivalent to 214 mg/kg bw based on the assumption of default body weight as 70 kg and treated with supportive measurements. In the same case reports of 14 accidental or deliberate ingestion of potassium chlorate the patients that survive to highest doses as 1428 mg/kg bw (100 g ingested) 642 mg/kg bw (45 g ingested) or 428.57 mg/kg bw (30 g ingested) based on assumption of default body weight as 70 kg underwent treatment by hemodialysis or peritoneal dialysis (Helliwell and Nunn 1979).

The human case reports showed that the lowest lethal doses are < 300 mg/kg bw supporting classification as Acute Tox. 3 according to CLP criteria. These levels are observed in case reports where hemodialysis or peritoneal dialysis were not applied. New mechanistic studies showed that methylene blue, the antidote for methemoglobinemia produced by chlorate and used in 1960-1980 is not efficient in chlorate poisoning. It was shown in vitro that the chlorates induce concentration-dependent oxidation of haemoglobin. The methemoglobin formation is followed by denaturation of the globin, a cross-linking of erythrocyte membrane protein and inactivation of membrane enzymes. The high sensitivity of glucose-6-phosphate dehydrogenase to denaturation by chlorate explains the inefficacy of methylene blue to reduce MetHb formed, as the antidotal effect of methylene blue depends on NADPH formed mainly by the oxidation of glucose-6-phosphate. The observed changes occur only in the presence of MetHb which forms a destabilising complex with chlorate. MetHb thus autocatalytically increases MetHb formation and destruction of the erythrocyte (Steffen and Wetzel 1993). In chlorate poisoning, haemodialysis is recommended not only as renal replacement therapy but also for removal of the toxic agent and increase the survival of intoxicated patients.

Overall conclusion: Despite the limitations of the case reports reviewed, RAC cannot disregard the studies that showed mortality at doses below 300 mg/kg bw and that support classification as Acute Tox. 3, H301. The cases that showed survival at higher doses were treated by haemodialysis or peritoneal dialysis that proved to be recommended treatment in chlorate poisoning both for preventing the acute renal failure and for removal of the toxic agent.

In the view of these data, RAC agreed that sodium chlorate should be classified as **Acute Tox 3; H301, adding an ATE = 100 mg/kg bw** by using the converted Acute Toxicity point Estimate (cAtpE) for category 3 based on human case reports.

10.2 Acute toxicity - dermal route

Not assessed in this CLH-proposal.

10.3 Acute toxicity - inhalation route

Not assessed in this CLH-proposal.

10.4 Skin corrosion/irritation

Hazard class not assessed in this CLH-proposal.

10.5 Serious eye damage/eye irritation

Hazard class not assessed in this CLH-proposal.

10.6 Respiratory sensitisation

Hazard class not assessed in this CLH-propsal.

10.7 Skin sensitisation

Hazard class not assessed in this CLH-proposal.

10.8 Germ cell mutagenicity

Hazard class not assessed in this CLH-proposal.

10.9 Carcinogenicity

Hazard class not assessed in this CLH-proposal.

10.10 Reproductive toxicity

Hazard class not assessed in this CLH-proposal.

10.11 Specific target organ toxicity-single exposure

Hazard class not assessed in this CLH-proposal.

10.12 Specific target organ toxicity-repeated exposure

Hazard class not assessed in this CLH-proposal.

10.13 Aspiration hazard

Hazard class not assessed in this CLH-proposal.

11 EVALUATION OF ENVIRONMENTAL HAZARDS

In water sodium and potassium are naturally present and the amounts added with the test substance are not considered to have an impact on the total concentration and on the test result. Sodium is the most abundant of the alkali metals, the fifth most abundant metal in the Earth's crust with an average value of 22,700 mg/kg, and the principal cation in sea water, at a typical concentration 10,500 mg/l. Sodium values in stream water range over four orders of magnitude, from 0.23 to 1284 mg/l, with a median value of 6.58 mg/l. Potassium occurs in various minerals, from which it may be dissolved through weathering processes. Seawater contains about 400 mg/l potassium. It tends to settle, and consequently ends up in sediment mostly. Rivers generally contain about 2-3 mg/l potassium.

The counter ion present is therefore not relevant for the test results and will not contribute to the effects caused by the substance.

Many physico-chemical properties are not relevant or cannot be derived for inorganic substances. Water solubility was measured for both substances and as can be seen in the table below, both substances are readily soluble in water. There is also limited aquatic ecotoxicity data available for potassium chlorate. For both sodium- and potassium chlorate studies with marine algae were performed. From those studies it can be concluded that both substances are non-toxic to marine algae with NOEC values greater than 100 mg/l.

Sodium and potassium chlorate are strong acids with pKa values in the range of -1 to -3 (theoretical range[5]), meaning that both sodium and potassium chlorate almost totally dissociated in water, producing sodium/potassium cations and chlorate anions.

The conclusions drawn for sodium chlorate are also valid for potassium chlorate and vice versa.

All results depicted in the tables in the sections below are expressed as test substance (Na- or $KClO_3$) as well as Chlorate ion. Results have been converted to test substance or Chlorate ion by molecular weight of the different species.

MW (g/mol):

- $NaClO_3$: 106.44
- $KaClO_3$: 122.55
- ClO_3^-: 83.45

Example calculation:

EC50 = 1000 mg $NaClO_3$/l
1000/106.44*83.45 = 784 mg ClO_3^-/l

11.1 Rapid degradability of organic substances

Not applicable since sodium chlorate is an inorganic compound.

11.2 Environmental transformation of metals or inorganic metals compounds

Not applicable since sodium chlorate is not a metal compound.

11.3 Environmental fate and other relevant information

[5] Expert statement: An experimental determination of the dissociation constant of sodium chlorate is not possible due to its strong acidity and because the sodium chlorate decomposes on acidification and produces toxic chlorine dioxide and chlorine gas.
Based on the available information, the pK, of sodium chlorate is in the range of -1 to approx. -3 (Weissenfeld, 2004).

11.3.1 Ready biodegradability

Biotic conversions of sodium chlorate, an inorganic substance should not be assessed in standard OECD TG 301 tests for ready biodegradability, and OECD TG 302 tests for inherent biodegradability because these tests only detect biodegradation of organic compounds under aerobic conditions. The attempt of L'Haridon (2003) to detect biodegradation of sodium chlorate in the Sturm test (OECD TG 301 B) using a specific analysis of chlorate was therefore unsuccessful. Degradation of sodium chlorate in the Sturm test was though to be possible by L'Haridon (2003) because of the existence of anaerobic niches within the sludge particles used as inoculum. These anaerobic niches do occur in properly operated biological wastewater treatment plants (high activated sludge concentrations and low oxygen levels of~2 mg/L) but not in an OECD TG 301 tests (low level of activated sludge and oxygen levels of >>9 mg/L). Moreover, the amount of biodegradable reducing agents in a standard OECD TG 301 test is limiting also preventing chlorate reduction.

"Ready" biodegradability of sodium chlorate transformation can be shown easily using the methodology of the Closed Bottle test (OECD TG 301 D) with one major modification (van Ginkel et al, 1995). The test was modified by adding excess amounts of reducing agents such as fatty acids, amino acids, carbohydrates. A minor part of the reducing agent was oxidized with the molecular oxygen present in the bottles thereby creating anaerobic conditions. The tests were inoculated with low concentrations of activated sludge, soil, digested sludge or dilutions of river and ditch water in line with the OECD TG 301. Complete removal of chlorate was achieved within 28 days with all inocula tested and most reducing agents.

The ease with which chlorate reduction occurs naturally is also demonstrated by Bryan and Rohlich (1954) who used chlorate reduction as a measure for the Biological Oxygen Demand (BOD) showing that chlorate is rapidly reduced by microorganisms using organic compounds as carbon and energy source present in sewage.

A valid ready biodegradability test result is not available for sodium chlorate because chlorate is an electron acceptor like molecular oxygen. Nevertheless all aspects important for achieving a ready biodegradability test result i.e. ultimate (complete) biodegradation, rate of biodegradation and number and occurrence of competent micro-organisms present in "unacclimated" ecosystems and biological treatment plants have been investigated (see above). Ready biodegradability tests only detect growth-linked biodegradation. Microorganisms are capable of growth on sodium chlorate in the presence of reducing agents under anaerobic conditions. The biodegradation pathway proves that chlorate is reduced completely to chloride. The biodegradation kinetics of chlorate have been determined with mixed and pure cultures. The maximum growth rates of chlorate reducing microorganisms range from 0.04 to 0.56h^{-1}, which is comparable or much higher than growth rates of nitrifying bacteria. Ammonium is oxidized readily in OECD TG 301 tests due to these nitrifying bacteria. Painter and King (1983) used a model based on the Monod equation to interpret the biodegradation curves in ready biodegradability tests. According to this model, growth rates of competent micro-organisms of 0.01 h^{-1} or higher do result in a ready biodegradation of the test substance. Reduction of chlorate has been detected in terrestrial ecosystems, fresh water, marine environment, compost, and aquifers. These findings demonstrate the wide distribution of chlorate-reducing micro-organisms and that sodium chlorate can be considered as readily biodegradable.

No standard tests are available for sodium chlorate, but from tests only deviating from OECD TG 301 TG methodology with respect to the absence of oxygen (van Ginkel et al., 1995) it can be concluded that sodium chlorate is readily biodegradable.

Hence, in applying a weight of evidence approach to this specific case it can be concluded that the substance should be considered as rapidly degradable for classification purposes.

Up to recently, perchlorate and chlorate were thought to be primarily antropogenic. Recent evidence makes a strong case for more widespread natural occurrence of perchlorate, outside of the long-established occurrence in caliches of the Atacama Desert in Chile. Improved sensitivity of perchlorate detection techniques shows widespread existence of ppb levels of perchlorate. Not all perchlorate

detected could be traced to anthropogenic sources. Natural perchlorate in soils is rare but occurs in other arid environments at levels up to 0.6 weight %. In the southern high plains groundwater, perchlorate is better correlated with iodate, known to be of atmospheric origin, compared to any other species (Dasgupta et al, 2005).

Natural perchlorate may be formed from chloride aerosol by electrical discharge and by exposing aqueous chloride to high concentrations of ozone (Bao and Gu, 2004; Bohlke et al 2005). Information regarding the perchlorate formation process is however, still largely unknown. Perchloric acid is the stable end product of the atmospheric chemistry because of its resistance to photolysis (Simonaitis and Heicklen, 1975) and occurs in aerosols in stratosphere of the earth at 0.5 to 5 parts per trillion (Murphy and Thomson, 2000). Perchlorate was also detected in rain and snow samples. This strongly suggests that some perchlorate is formed in the atmosphere and a natural perchlorate background of atmospheric origin should exist. In soils and surface waters perchlorate is reduced via chlorate. Chlorate is therefore part of natural chloro-oxy acid cycle (Figure 1). The existence of a chloro-oxy acid cycle does explain the enormous potential for chlorate reduction in the environment.

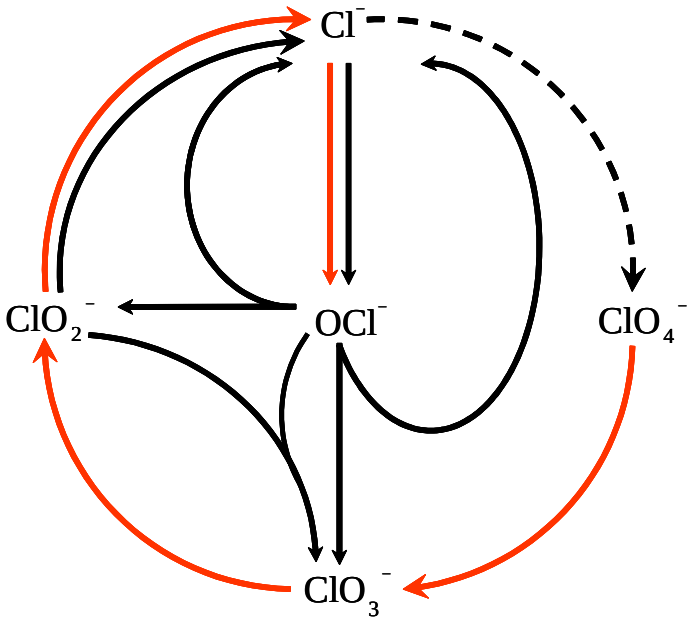


Figure 1: Chloro-oxo acid cycle. The dashed arrow represents the recent findings of perchlorate formation in aerosols. The red arrow are reactions catalysed by enzymes present in (per)chlorate respiring bacteria, nitrate reductases and peroxidases (formation of hypochlorite). The black arrows indicate chemical reactions occurring under ambient environmental temperatures.

11.3.2 Hydrolysis

Sodium chlorate is highly soluble in water (696-736 g/L at 20°C for pH 4.49 to 8.70 at 20°C, see table 7). Sodium chlorate in aqueous solutions is known for its chemical stability under environmental conditions (Urbanski 1998).

Based on the chemical structure it is expected that sodium chlorate is resistant to hydrolysis. Due to its chemical structure, sodium chlorate is considered as stable in sterile water whatever the pH is. There are no relevant metabolites, degradation or reaction products that necessitate studies to answer this point.

Sodium chlorate is rapidly biodegradable. Studies on the hydrolysis as a function of the pH are therefore not required.

11.3.3 Other convincing scientific evidence

11.4 Bioaccumulation

Although no measured data on bioaccumulation were identified, based on the environmental fate and behaviour of the substance (the complete dissociation in water due to low dissociation constant and the high water solubility) no significant bioaccumulation is expected.

11.5 Acute aquatic hazard

For all trophic levels, tests according to international standard guidelines were performed in compliance with GLP.

Table 6: Summary of relevant information on acute aquatic toxicity

IUCLID section	Method	Species	Test material	Results Expressed as$Na/KClO_3$	Results Expressed as ClO_3^-	Remarks	Reference	Klimish score	Adequacy of study
6.1.1	EPA OPP 72-1	*Oncorhynchus mykiss*	Sodium chlorate	LC_{50} (96h) >1000 mg/l (nominal)	LC_{50} (96h) >784 mg/l (nominal)	Fresh-water species	Study report (1991a)	1	Key study
6.1.1	EPA OPP 72-3	*Cyprinodon variegatus*	Sodium chlorate	LC_{50} (96h) >1000 mg/l (nominal)	LC_{50} (96h) >784 mg/l (nominal)	Marine species	Study report (1991c)	1	Key study
6.1.3	EPA OPP 72-2	*Daphnia magna*	Sodium chlorate	EC_{50} (48h) >1000 mg/l (nominal)	EC_{50} (48h) >784 mg/l (nominal)	Fresh-water species	Study report (1991d)	1	Key study
6.1.3	In-house method	*Mysidopsis bahia*	Sodium chlorate	LC_{50} (96h)> 1000 mg/l (nominal)	LC_{50} (96h)> 784 mg/l (nominal)	Marine species	Study report (1991f)	2	Key study
6.1.5	EPA OPP 122-2	*Selenastrum capricornutum*	Sodium chlorate	E_bC_{50} (72h) = 129 mg/l (nominal) E_bC_{50} (96h) = 133 mg/l (nominal)	E_bC_{50} (72h) = 101 mg/l (nominal) E_bC_{50} (96h) = 104 mg/l (nominal)	Fresh-water species	Study report (1991e)	1	Supporting study
6.1.5	According to own protocol	*Nitzschia closterium*	Potassium chlorate	15 mg $NO3^-$ /l: E_rC_{50} (72h) > 735 mg/l (nominal)	15 mg $NO3^-$ /l: E_rC_{50} (72h) > 500 mg/l (nominal)	Marine species	Stauber J.L. (1998)	2	Key study
6.1.6	OECD 221	*Lemna minor*	Sodium chlorate	Biomass growth: EC_{50} (7d) = 73.7 mg/l (nominal) Growth rate: EC_{50} (7d) = 134 mg/l (nominal) Biomass dry weight: EC_{50} (7d) = 128 mg/l (nominal)	Biomass growth: EC_{50} (7d) = 57.5 mg/l (nominal) Growth rate: EC_{50} (7d) = 105 mg/l (nominal) Biomass dry weight: EC_{50} (7d) = 100 mg/l (nominal)	Fresh-water species	Study report (2003)	1	Key study
6.1.9	U.S. EPA-FIFRA, Guideline 72-3	*Crassostrea virginica*	Sodium chlorate	EC_{50} (96h) > 1000 mg/l LC_{50} (96h) > 1000 mg/l (nominal)	EC_{50} (96h) > 784 mg/l LC_{50} (96h) > 1000 mg/l (nominal)	Marine species	Study report (1991g)	2	Other information
6.1.9	ISO/DC 20666	*Brachionus plicatilis*	Sodium chlorate	EC_{50} (96h) = 596 mg/l	EC_{50} (96h) = 467 mg/l	Marine species	Study report (2010b)	1	Supporting study

11.5.1 Acute (short-term) toxicity to fish

Five acute toxicity studies were found for fresh water fish of which four are valid and one is valid with restrictions (Toussaint, et al. (2001) because the test was not performed according to standard test protocol (see table 12). One valid test on marine fish was also found.

Table 7. Acute toxicity to fish

Method	Results Expressed as $Na/KClO_3$	Results Expressed as ClO_3^-	Test material	Remarks	Reference	Klimish score	Adequacy of study
GLP, Flow through test, 96 hours, according to EPA OPP 72-1 **Key study (fresh water)**	LC_{50} >1000 mg/l	LC_{50} >784 mg/l	Sodium chlorate	*Oncorhynchus mykiss*	Study report (1991a)	1	Key study
GLP, Flow through test, 96 hours, according to EPA OPP 72-1	LC_{50} >1000 mg/l	LC_{50} >784 mg/l	Sodium chlorate	*Lepomis macrochirus*	Study report (1991b)	1	Supporting study
GLP, Semi-static test, 96 hours, according to OECD 203	LC_{50} >1000 mg/l	LC_{50} >784 mg/l	Sodium chlorate	*Brachydanio rerio*	Study report (1991h)	1	Supporting study
GLP, Semi-static test, 96 hours, according to OECD 203	LC_{50} >1000 mg/l	LC_{50} >784 mg/l	Sodium chlorate	*Pimephales promelas*	Study report (1993)	1	Supporting study
96 hours test according to own protocol	LC_{50} = 2585 mg/l	LC_{50} = 2027 mg/l	Sodium chlorate	*Oryzias latipes*	Toussaint, et al. (2001)	2	Supporting study
GLP, Flow through test, 96 hours, according to EPA OPP 72-3 **Key study (marine)**	LC_{50} >1000 mg/l	LC_{50} >784 mg/l	Sodium chlorate	*Cyprinodon variegatus*	Study report (1991c)	1	Key study

All studies can be found in IUCLID in section 6.1.1

For all studies LC50s >1000 mg/l were observed. In the first two studies (Study report (1991a) and (1991b)) with *Oncorhynchus mykiss* and *Lepomis macrochirus* chemical analysis of the stock solution was performed. The measured concentrations were 105 and 103% of the nominal concentration and therefore the nominal test concentrations were used to derive the endpoints. Except of the stock solution, no chemical analysis was performed during the test. But it was considered that the concentration of sodium chlorate was stable during the test.

The LC_{50} for fresh water fish is greater than 1000 mg/l.

Similar to fresh water fish , the LC_{50} of sodium chlorate for marine fish (Study report, 1991c) was also greater than the highest test concentration of 1000 mg/l. This indicates that there is no influence of the marine conditions on the toxicity of sodium chlorate.

11.5.2 Acute (short-term) toxicity to aquatic invertebrates

Two valid studies with *Daphnia magna* are available (see table 13). Both studies were performed in compliance with GLP and according to standard protocol. In both studies chemical analyses were carried out, but Study report (1991d) only analyses on the stock solution were performed. In study report (1995), the endpoint was expressed in mg chlorate ion per liter, this was transformed to mg sodium chlorate per liter for the purpose of this classification proposal.. The original value was 919.3 mg chlorate/l. The results of the study performed in 1995 were heterogeneous and must therefore be

considered reliable with restrictions, but nevertheless the results confirm the outcome of the study report of 1991d.

One study valid with restrictions is available for the marine crustacean *Mysidopsis bahia* (Study report, 1991f).

Table 8. Acute toxicity to invertebrates

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
Flow through test, 48 hours, according to EPA OPP 72-2 **Key study (fresh water)**	EC_{50} >1000 mg/l	EC_{50} >784 mg/l	Sodium chlorate	*Daphnia magna*	Study report (1991d)	1	Key study
Static test, 48 hours, according to EPA OPP 72-2	EC_{50} = 1172 mg/l	EC_{50} = 919.3 mg/l	Sodium chlorate	*Daphnia magna*	Study report (1995)	2	Supporting study
In-house method **Key study (marine)**	LC_{50} > 1000 mg/l	LC_{50} >784 mg/l	Sodium chlorate	*Mysidopsis bahia*	Study report (1991f)	2	Key study

All studies can be found in IUCLID in section 6.1.3

The EC50 for fresh water and marine invertebrates is greater than 1000 mg/l, showing that sodium chlorate is not harmful to aquatic organisms

11.5.3 Acute (short-term) toxicity to algae or other aquatic plants

Algae

Two studies on sodium chlorate are available, one on *Selenastrum capricornutum* and one on *Scenedesmus subspicatus* were found (see table 14). One was valid without restrictions (study report, 1991e) and the other one was valid with restrictions because not all details on the results were provided.

The E_bC_{50}-value of the study with *Scenedesmus subspicatus* (Study report, 2004c) was higher than 1592.3 mg/l, because 50% inhibition was not reached an E_rC_{50} could not be determined. The Fe_2O_3 present in the test substance interfered with the spectrofotometrical measurements and increased the extinction, this is not considered to have a significant impact on the results of this test. In the calculation of the biomass a correction is made for the higher extinctions measured at t=0. The higher values at t=0 do not have an influence on the slope of the growth curve, which is used for the calculation of the E_bC_{50}.

Table 9.Toxicity to fresh water aquatic algae

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
96 hours test according to EPA OPP 122-2	Cell growth: E_bC_{50}-72h = 129 mg/l E_bC_{50}-96h = 133 mg/l	Cell growth: E_bC_{50}-72h = 101 mg/l E_bC_{50}-96h = 104 mg/l	Sodium chlorate	*Selenastrum capricornutum*	Study report (1991e)	1	Supporting study
72 hours test according to OECD 201	Biomass: E_bC_{50} > 1592.3 mg/l	Biomass: E_bC_{50} > 1248.4 mg/l	Sodium chlorate	*Scenedesmus subspicatus*	Study report (2004c)	2	Supporting study

All studies can be found in IUCLID in section 6.1.5

The lowest acute value for freshwater algae was found for *Selenastrum capricornutum*. The E_bC_{50} was 129 mg/l after 72 hours.

One valid test with marine algae is available (Study report, 2010a) (see table 15).

Table 10.Toxicity of sodium chlorate to marine algae

Method	**Results Expressed as $Na/KClO_3$**	**Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
72 hours test according to ISO 10253 guideline	EC_{50} > 1000 mg/l	EC_{50} > 784 mg/l	Sodium chlorate	*Skeletonema costatum*	Study report (2010a)	1	Supporting study

All studies can be found in IUCLID in section 6.1.5

Study report (2010a) was performed as a standard test with *Skeletonema costatum* according to guideline and GLP. Chemical analyses were performed on the test concentrations. The report found that *S. costatum* was not sensitive to sodium chlorate, with an EC50 greater than 1000 mg/l.

Two tests (valid with restriction) were found for marine algae performed with potassium chlorate (see table 16).

Table 11. Toxicity of potassium chlorate to marine algae

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
72 hours test according to own protocol with potassium chlorate	15 mg NO_3^-/l: E_rC_{50} > 1469 mg/l	15 mg NO_3^- /l: E_rC_{50} > 1000 mg/l	Potassium chlorate	*Dunaliella tertiolecta*	Stauber J.L. (1998b)	2	Supporting study
72 hours test according to own protocol with potassium chlorate	15 mg NO_3^-/l: E_rC_{50} > 735 mg/l	15 mg NO_3^- /l: E_rC_{50} > 500 mg/l	Potassium chlorate	*Nitzschia closterium*	Stauber J.L. (1998a)	2	Key study

All studies can be found in IUCLID in section 6.1.5

The tests were performed with potassium chlorate and originally the endpoints were expressed in mg chlorate/l. The original data for the EC_{50} was for *Dunaliella tertiolecta* > 1000 mg chlorate/l and for *Nitzschia closterium* > 500 mg chlorate/l. The endpoints presented in Table 16 are recalculated to mg potassium chlorate/l for comparison with the studies on sodium chlorate.

The test was carried out at three different nitrate levels namely <0.005, 1 and 15 mg nitrate/l. At the lower nitrate concentrations cell growth in the controls was not according to the standard criteria and these results cannot be used therefore. Only valid results are given in the table above corresponding to a concentration of nitrate used in the standard bioassay (i.e. 15 mg nitrate/l).

The difference in toxicity noted between marine and freshwater algae, appears to be related more to the relative difference in concentration of nitrate in freshwater and marine compartments than to different mechanisms of toxicity between species. The concentration of nitrate in the test water influences the effect concentration of chlorate indicating that competitive inhibition occurs between nitrate and chlorate with excess nitrate inhibiting chlorate toxicity. This is supported by the acute studies on marine species using chlorate at several nitrate concentrations.

Aquatic plants

One valid study was found for freshwater aquatic plants (see table 17).

Table 12. Toxicity to aquatic plants

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
7 days test according to OECD 221 **Key study (fresh water)**	Biomass growth: EC_{50} = 73.7 mg/l Growth rate: EC_{50} = 134 mg/l Biomass dry weight: EC_{50} = 128 mg/l	Biomass growth: EC_{50} = 57.5 mg/l Growth rate: EC_{50} = 105 mg/l Biomass dry weight: EC_{50} = 100 mg/l	Sodium Chlorate	*Lemna minor*	Study report (2003)	1	Key study

All studies can be found in IUCLID in section 6.1.6

Lemna minor is for sodium chlorate the most sensitive freshwater species tested .The lowest value for acute toxicity to freshwater plants is EC50 of 73.7 mg/l based on biomass growth of *Lemna minor*.

This indicates that sodium chlorate is not harmful to aquatic plants

11.5.4 Acute (short-term) toxicity to other aquatic organisms

One short-term study valid with restrictions was found for molluscs (see table 18). From this study (Study report, 1991g) it can be seen that marine molluscs are not sensitive to sodium chlorate with an EC_{50} value based on shell growth and an LC_{50} value both greater than 1000 mg/l.

Another study with the marine rotatoria *Brachionus plicatilis* is available (study report, 2010b). There was a dose dependent reduction in reproduction observed for *B. plicatilis*, when exposed to sodium chlorate. The EC50 was calculated to be 596 mg/l. Mortality of parent rotatoria was not observed at any concentration so EC50 for parent mortality is greater than 1000 mg/l.

Table 13. Toxicity to other aquatic organisms

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
96h test according to U.S. EPA-FIFRA, Guideline 72-3	EC_{50} > 1000 mg/l LC_{50} > 1000 mg/l	EC_{50} > 784 mg/l LC_{50} > 784 mg/l	Sodium chlorate	*Crassostrea virginica*	Study report, (1991g)	2	Other information
ISO/DC 20666	EC50 (96h) = 596 mg/l	EC50 (96h) = 467 mg/l	Sodium chlorate	*Brachionus plicatilis*	Study report (2010b)	1	Other information

All studies can be found in IUCLID in section 6.1.9

11.6 Long-term aquatic hazard

Table 14: Summary of relevant information on chronic aquatic toxicity

IUCLID section	Method	Species	Test material	Results Expressed as $Na/KClO_3$	Results Expressed as ClO_3^-	Remarks	Reference	Klimish score	Adequacy of study
6.1.2	OECD 210	*Danio rerio*	Sodium chlorate	NOEC (36d) ≥ 500 mg/l (nominal)	NOEC (36d) ≥ 392 mg/l (nominal)	Fresh-water species	Study report (2004a)	1	Key study
6.1.4	OECD 211	*Daphnia magna*	Sodium chlorate	NOEC (21d) ≥ 500 mg/l (nominal)	NOEC (21d) ≥ 392 mg/l (nominal)	Fresh-water species	Study report (2004b)	1	Key study
6.1.5	EPA OPP 122-2	*Selenastrum capricornutum*	Sodium chlorate	Cell growth: NOEC (96h) = 62.5 mg/l (nominal)	Cell growth: NOEC (96h) = 49.0 mg/l (nominal)	Fresh-water species	Study report (1991e)	1	Supporting study
6.1.5	72 hours test according to own protocol based in ISO	*Phaeodactylum tricornutum*	Sodium chlorate	NOE_bC = 64 mg/l NOE_rC = 128 mg/l (nominal)	NOE_bC = 50 mg/l NOE_rC = 100 mg/l (nominal)	Marine species	Study report (1994b)	2	Supporting study
6.1.5	72 hours test according to own protocol with potassium chlorate	*Nitzschia closterium*	Potassium chlorate	15 mg $NO3^-$/l: NOE_rC = 147 mg/l (nominal)	15 mg $NO3^-$/l: NOE_rC = 100 mg/l (nominal)	Marine species	Stauber J.L. (1998a)	2	Key study
6.1.6	OECD 221	*Lemna minor*	Sodium chlorate	NOEC (7d) = 10 mg/l	NOEC (7d) = 7.8 mg/l	Fresh-water species	Study report (2003)	1	Key study
6.1.9	ISO/DC 20666	*Brachionus plicatilis*	Sodium chlorate	EC10 (96h) = 21 mg/l (nominal) NOEC (96h) = 46 mg/l (nominal)	EC10 (96h) = 16.5 mg/l (nominal) NOEC (96h) = 36 mg/l (nominal)	Marine species	Study report (2010b)	1	Supporting study

11.6.1 Chronic toxicity to fish

One chronic fish study of sodium chlorate using aan early life stage test on *Danio rerio* (see table 20) is available The test was performed according to the OECD guideline 210 without deviations and in compliance with GLP. Chemical analyses showed that the test substance concentrations were stable during the test and close to nominal concentrations.

All embryos hatched at the highest concentration tested of 500 mg/l as well as in the control and post-hatch mortality was less than that of the control, the NOEC was considered to be at or greater than the highest concentration tested. No teratogenic malformations were noted for any larvae at any concentration.

Based on results from weight and length, the LOEC could not be calculated and the NOEC was determined as greater than or equal to the highest concentration tested, 500 mg/l.

Table 15.Chronic toxicity to fish

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
36 days flow-through test according to OECD 210 **Key study**	NOEC ≥ 500 mg/l	NOEC ≥ 392 mg/l	Sodium chlorate	*Danio rerio*	Study report (2004a)	1	Key study

All studies can be found in IUCLID in section 6.1.2

The NOEC for fish is equal or greater than 500 mg/l. This result shows that sodium chlorate is also not harmful in the early life stages of fish.

11.6.2 Chronic toxicity to aquatic invertebrates

One chronic study with *Daphnia magna* was found (see table 21). The test was performed according to OECD guideline 211 and in compliance with GLP . Chemical analyses showed that the test substance concentrations were stable and close to nominal concentrations. The test was therefore considered valid without restrictions.

Reproductive output and length of adults at the end of the study were lower in the control than in any other concentration tested. Using Dunnett's and Bonferroni-t tests, the LOEC based on weight was found to be greater than 500 mg/l. Based on these results the NOEC for reproduction, weight and length is 500 mg/l.

Table 16.Chronic toxicity to invertebrates

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
GLP, 21 days semi-static test according to OECD 211	NOEC ≥ 500 mg/l	NOEC ≥ 392 mg/l	Sodium chlorate	*Daphnia magna*	Study report (2004b)	1	Key study

All studies can be found in IUCLID in section 6.1.4

The NOEC for invertebrates is equal or greater than 500 mg/l. This result shows that sodium chlorate has also no effect on growth and reproduction of *Daphnia magna* up to 500 mg/l

11.6.3 Chronic toxicity to algae or other aquatic plants

Algae

Three studies, with fresh water species, one on *Selenastrum capricornutum* and two on *Scenedesmus subspicatus* were found (see table 22). One was valid without restrictions (Study report, 1991e) and two were valid with restrictions because not all details on the results were provided.

The NOEC value of the study with *Scenedesmus subspicatus* (Study report, 2004c) was 396.9 mg/l based on biomass and 1592.3 mg/l based on growth rate. The Fe_2O_3 present in the test substance interfered with the spectrofotometrical measurements and increased the extinction, this is not considered to have a significant impact on the results of this test. In the calculation of the biomass a correction is made for the higher extinctions measured at t=0. The higher values at t=0 do not have an influence on the slope of the growth curve, which is used for the calculation of the NOEC.

The same species was tested in Study report (1994a). The original value for the NOEC was 1569 mg chlorate/l.

Table 17.Toxicity to fresh water aquatic algae

Method	Results Expressed as $Na/KClO_3$	Results Expressed as ClO_3^-	Test material	Remarks	Reference	Klimish score	Adequacy of study
96 hours test according to EPA OPP 122-2	Cell growth: NOEC = 62.5 mg/l	Cell growth: NOEC = 49 mg/l	Sodium chlorate	*Selenastrum capricornutum*	Study report (1991e)	1	Supporting study
72 hours test according to OECD 201	Biomass: NOEC = 396.9 mg/l Growth rate: NOEC = 1592.3 mg/l	Biomass: NOEC = 311 mg/l Growth rate: NOEC = 1248.4 mg/l	Sodium chlorate	*Scenedesmus subspicatus*	Study report (2004c)	2	Supporting study
72 hours test according to OECD 201	NOEC = 2001 mg/l	NOEC = 1569 mg/l	Sodium chlorate	*Scenedesmus subspicatus*	Study report (1994a)	2	Supporting study

All studies can be found in IUCLID in section 6.1.5

The lowest NOEC for freshwater algae was found for *Selenastrum capricornutum* and was 62.5 mg/l.

For sodium chlorate, two tests with marine algae are available: one valid study (Study report, 2010a) and one valid with restriction (Study report, 1994b) (see table 23). Study report (2010a) is a standard test with *Skeletonema costatum* according to ISO 10253 guideline and in compliance with GLP. Chemical analyses were performed on the test concentrations. *S. costatum* was not sensitive to sodium chlorate, with a NOEC greater than or equal to 1000 mg/l. A test performed with *Phaeodactylum tricornutum* found a NOEC of 64 mg sodium chlorate/l for biomass and a NOEC of 128 mg sodium chlorate/l for the growth rate.

Furthermore, Rosemarin *et al.*, 1986 and 1994, studied the effects of sodium chlorate in a mesocosm study. The test was considered to be invalid because the study was not performed according to standard methods and not in compliance with GLP. Though certain aspects were described in detail, there are parts which are not clear e.g. on method and materials. It is also not certain that replicates contain the same number and type of species; a) *Fucus vesiculosus* on original stone substrate with associated organisms were put in the pools. It is not known what these associated organisms were, wether a similar number was introduced into each pool and if they had an impact on the test result. b) Raw seawater was let into the pools. There are no details on the substances present in this water and it is not known if this water was treated before it entered the pools.

The EC50 after 6 months of exposure and a NO_3 concentration of < 0.039 mg N/l, for apical growth of *F. vesiculosus* is ca. 80 µg ClO_3^-/l and clear negative effects were seen at about 15-20 µg ClO_3^-/l, which could be seen as 6 months-LOEC. As the study was not performed according to standard methods and the duration of the study was much longer than standard duration, the results are difficult to compare to standard test results.

Table 18.Toxicity of sodium chlorate to marine algae

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
72 hours test according to ISO 10253 guideline	NOEC ≥ 1000 mg/l	NOEC ≥ 784 mg/l	*Skeletonema costatum*	Study report (2010a)	1	Supporting study
72 hours test according to own protocol based in ISO	NOE_bC = 64 mg/l NOE_rC = 128 mg/l	NOE_bC = 50 mg/l NOE_rC = 100 mg/l	*Phaeodactylum tricornutum*	Study report (1994b)	2	Supporting study
Own method – 6 months, mesocosm	EC50 ca. 102 µg ClO_3^-/l	EC50 ca. 80 µg/l	*Fucus vesiculosus*	Rosemarin, *et al.*, 1986 and 1994	3	Invalid study

All studies can be found in IUCLID in section 6.1.5

Two tests (valid with restriction) were found for marine algae performed with potassium chlorate (see table 24).

Table 19. Toxicity of potassium chlorate to marine algae

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
72 hours test according to own protocol with potassium chlorate	15 mg NO_3^-/l: NOE_rC = 735 mg/l	15 mg NO_3^-/l: NOE_rC = 500 mg/l	*Dunaliella tertiolecta*	Stauber J.L. (1998b)	2	Key study
72 hours test according to own protocol with potassium chlorate	15 mg NO_3^-/l: NOE_rC = 147 mg/l	15 mg NO_3^-/l: NOE_rC = 100 mg/l	*Nitzschia closterium*	Stauber J.L. (1998a)	2	Key study

All studies can be found in IUCLID in section 6.1.5

The tests were performed with potassium chlorate and originally the endpoints were expressed in mg chlorate/l. The original data for the NOEC based on growth rate was for *Dunaliella tertiolecta* > 500 mg chlorate/l and for *Nitzschia closterium* > 100 mg chlorate/l. The endpoints presented in Table 24 are recalculated to mg potassium chlorate/l for comparison with the studies on sodium chlorate.The tests were carried out at three different nitrate levels namely <0.005, 1 and 15 mg nitrate/l. At the lower nitrate concentrations cell growth in the controls was not according to the standard criteria and these results cannot be used therefore. Only valid results are given in the table above.

The concentration of nitrate in the test water influences the effect concentration of chlorate indicating that competitive inhibition occurs between nitrate and chlorate with excess nitrate inhibiting chlorate toxicity. This is supported by the acute studies on marine species using chlorate at several nitrate concentrations.

When comparing results from different marine algae toxicity studies, comparison should be made between studies performed under the same standard conditions (i.e. nitrate concentrations) as much as possible. The chlorate anion is not directly toxic; the mechanism of chlorate toxicity in plants and algae is indirect. The toxicity of chlorate is coupled to its reduction to chlorite and this reduction is linked to an active, functioning nitrate reductase system. The activity of this reductase system is related to the concentration of nitrate present, therefore it is important to compare studies with similar levels of nitrate.

All tested marine algae species showed similar sensitivity to chlorate under standard test conditions, with NOEC values for growth rate ≥ 100 mg ClO^{3-}/l (128 mg/l sodium chlorateor 147 mg/l potassium chlorate) in a test using standard nitrate concentrations.

Under standard test conditions with standard nitrate concentrations chlorate is not harmful to marine algae.

Aquatic plants

One valid study on sodium chlorate was found for freshwater aquatic plants (see table 25). The NOEC for fresh water aquatic plants is 10 mg/l.

Table 20. Toxicity to aquatic plants

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
7 days test according to OECD 221 **Key study (fresh water)**	Biomass growth: NOEC = 10 mg/l Growth rate: NOEC = 10 mg/l Biomass dry weight: NOEC = 10 mg/l	Biomass growth: NOEC = 7.8 mg/l Growth rate: NOEC = 7.8 mg/l Biomass dry weight: NOEC = 7.8 mg/l	Sodium chlorate	*Lemna minor*	Study report (2003)	1	Key study

All studies can be found in IUCLID in section 6.1.6

Lemna minor is the most sensitive freshwater species tested to sodium chlorate.The lowest value for chronic toxicity to freshwater plants is 10 mg sodium chlorate /l based on *Lemna minor*.

11.6.4 Chronic toxicity to other aquatic organisms

One long-term study (valid without restrictions) is available for the rotifer *Brachionus plicatilis* (see table 26). This study was performed according to standard guideline ISO/DC 2066 in compliance with GLP. *B. plicatilis* turned out to be the most sensitive marine species with an EC_{10} of 21 mg/l.

Table 21. Toxicity to other aquatic organisms

Method	**Results Expressed as $Na/KClO_3$**	**Results Expressed as ClO_3^-**	**Test material**	**Remarks**	**Reference**	**Klimish score**	**Adequacy of study**
96h test according to ISO/DC 20666 **Key study (marine)**	EC_{10} = 21 mg/l NOEC = 46 mg/l	EC_{10} = 16.5 mg/l NOEC = 36.1 mg/l	Sodium chlorate	*Brachionus plicatilis*	Study report, (2010b)	1	Supporting study

All studies can be found in IUCLID in section 6.1.9

11.7 Comparison with the CLP criteria

11.7.1 Acute aquatic hazard

Acute aquatic toxicity data are available for all three trophic levels (fish, invertebrates, and algae).

The LC50_96h values obtained for fish (freshwater and marine water) for sodium chlorate were all greater than 1000 mg/l. EC50_48h obtained from two studies performed according to EPA OPP 72-2 and in compliance with GLP were greater than 1000 mg/L for *Daphnia magna*. Similarly, a toxicity test to the marine crustacean *Mysidopsis bahia* showed LC50_96h > 1000 mg/L.

Algae species (freshwater and marine) were demonstrated to be more sensitive to sodium chlorate than fish (freshwater and marine water).The lowest acute value for algae was found for *Selenastrum capricornutum* from a test performed according to EPA OPP 122-2. The sodium chlorate E_bC50_72h was 129 mg/L.

Concerning other freshwater aquatic organisms, there is one valid study on aquatic plants performed according to OECD 221 available. The sodium chlorate EC50_7d (biomass growth) of 73.7 mg/L was obtained for *Lemna minor*.

Two marine studies on two different taxonomic groups are also available. In marine molluscs *Crassostrea virginica* the EC_{50}_96h value based on shell growth and LC_{50}_96h value for sodium chlorate were both greater than 1000 mg/L . In the rotifer *Brachionus plicatilis* the EC50_96h for sodium chlorate was 596 mg/L .

These species cover a wide range of trophic levels and taxa and are considered as surrogate for all aquatic organisms. The acute aquatic toxicity based on the lowest of the available toxicity values is between 10 and 100 mg/L. It corresponds to EC50_7d (biomass growth) of 73.7 mg/L obtained with *Lemna minor* (study performed with sodium chlorate). These values are all above 1 mg/L which is the classification cut-off for category Acute 1.

As a conclusion, sodium chlorate is not classified for the acute aquatic hazard.

11.7.2 Long-term aquatic hazard (including bioaccumulation potential and degradation)

Sodium chlorate has a harmonised classification as Aquatic Chronic 2 (H411) and is included in the Annex VI of the CLP regulation.

Sodium chlorate is highly soluble in water (696-736 g/L at 20°C for pH 4.49 to 8.70 at 20°C, see table 7). Sodium chlorate in aqueous solutions is known for its chemical stability under environmental conditions (Urbanski 1998). Based on the chemical structure it is expected that sodium chlorate is resistant to hydrolysis.
Sodium chlorate is considered to be rapidly biodegradable based on non-standard tests were oxygen was absent (van Ginkel et al., 1995). The maximum growth rates of chlorate reducing microorganisms range from 0.04 to 0.56h^{-1}, growth rates of competent micro-organisms of 0.01 h^{-1} or higher do result in a ready biodegradation of the test substance.

Although no measured data on bioaccumulation were identified, based on the environmental fate and behaviour of the substance (the complete dissociation in water and the high water solubility) no significant bioaccumulation is expected (BCF < 500).

Chronic toxicity data are available for all three trophic levels (fish, invertebrates, and algae).

In a chronic fish study performed according to OECD guideline 210 the NOEC_36 d was equal to or greater than 500 mg/l sodium chlorate. Similarly to the chronic toxicity fish test, no effect was observed at the highest concentration tested i.e. 500 mg/l sodium chlorate in a chronic invertebrate toxicity test according to OECD guideline 211 (*Daphnia magna* Reproduction Test). Therefore, NOEC_21d for reproduction, weight and length was equal to or greater than 500 mg/l sodium chlorate.

Algae species (freshwater and marine) were demonstrated to be more sensitive to sodium chlorate than fish and invertebrates. The lowest NOEC was found for *Selenastrum capricornutum* with a NOEC_96h of 62.5 mg/l.

Concerning other freshwater aquatic organisms, one valid study according to OECD 221 was available on *Lemna minor*. It was more sensitive compared to algae with a NOEC_7d (growth rate) of 10 mg/l.

Two other taxonomic groups of marine organisms were tested as well. Molluscs (*Crassostrea virginica*) were not sensitive to sodium chlorate at 1000 mg/l in a short-term test (96h). The rotifer *Brachionus plicatilis* was the most sensitive marine species with a NOEC_96h of 46 mg/l based on reproduction.

These species cover a wide range of trophic levels and taxa and are considered as surrogate for all aquatic organisms. The chronic aquatic toxicity based on the lowest of all the available toxicity values is above 1 mg/l and correspond to NOEC_7d (growth rate) of 10 mg/l sodium chlorate obtained with *Lemna minor*.

For non-rapidly degradable substances for which there are adequate chronic toxicity data available, the classification cut-off for category Chronic 2 is 1 mg/l. For rapidly degradable substances for which there are adequate chronic toxicity data available, the classification cut-off for category Chronic 3 is also 1 mg/l.

Adequate chronic toxicity data are available for all three trophic levels and the lowest chronic value is above 1 mg/l. Sodium chlorate is considered rapidly degradable as described in section 11.3.1, but even if sodium chlorate would be considered as non rapidly degradable in the aquatic environment, it does not lead to any classification for the chronic aquatic hazard.

As a conclusion, sodium chlorate does not need to be classified for the chronic aquatic hazard.

11.8 CONCLUSION ON CLASSIFICATION AND LABELLING FOR ENVIRONMENTAL HAZARDS

The observed acute aquatic toxicity for sodium chlorate is above the cut-off criterion of 1 mg/l. **Sodium chlorate does therefore not need to be classified for the acute aquatic hazard.**

Adequate chronic toxicity data are available for all three trophic levels. The chronic aquatic toxicity for sodium chlorate is above the cut-off criterion of 1 mg/l. Even if a worst-case considering that sodium chlorate is not rapidly degradable in the aquatic environment is applied, **sodium chlorate does therefore not need to be classified for the chronic aquatic hazard.**

As a conclusion, no classification for environmental hazards is warranted for sodium chlorate according to the criteria in Annex I of the CLP Regulation (Commission Regulation (EU) No 286/2011).

RAC evaluation of aquatic hazards (acute and chronic)

Summary of the Dossier Submitter's proposal

General information

Sodium chlorate is currently listed in Annex VI of Regulation (EC) No 1272/2008 with a classification for environment hazard as Aquatic Chronic 2 (H411). The mesocosm study previously used for this classification was not considered valid as evaluated in the REACH registration dossier and by the DS. The available data that is considered valid for sodium chlorate, as presented in CLP report, do not support classification for hazards to the aquatic environment.

Read across justification

In water, sodium and potassium are naturally present and the amounts added with the test substance in experimental scenarios are not considered to have an impact on the test result. Sodium is the fifth most abundant alkali metal in the Earth's crust (22.700 mg/kg) and the principal cation in sea water (10.500 mg/L). Sodium values in stream water are from 0.23 to 1284 mg/ L (median value: 6.58 mg/L). Potassium occurs in various minerals, from which it may be dissolved through weathering processes. Sea water contains about 400 mg/L potassium. It tends to settle, and consequently ends up mostly in sediment. Rivers generally contains about 2-3 mg/L potassium. The counter ion present is therefore not relevant for the test results and will not contribute to the effects caused by the substance.

Water solubility was measured for both substances and has shown that both substances are highly soluble in water (see Table below).

There is also limited aquatic ecotoxicity data available for potassium chlorate. In the CLH report, studies with marine algae were available for both sodium and potassium chlorate. Based on these studies the DS concluded that both substances share toxicological profile, being non-toxic to marine algae with NOEC values greater than 100 mg/L (see Table below).

Both sodium and potassium chlorate strongly dissociate with pKa values in the range of -1 to -3 (theoretical range), meaning that both substances almost totally dissociate in water, producing sodium/potassium cations and chlorate anions.

Table: *A brief comparison of sodium and potassium chlorate*

Measure	**Sodium chlorate**	**Potassium chlorate**
Water solubility (g/L at 20 °C)	696 - 736	69.9
Toxicity values (mg/L) for marine algae	*Skeletonema costatum* E_rC_{50} > 1000 NOE_rC > 1000	*Dunaliella tertiolecta* E_rC_{50} > 1469 (15 mg NO_3^-/L) NOE_rC = 735 (15 mg NO_3^-/L) Nitzschia closterium E_rC_{50} > 735 (15 mg NO_3^-/L) NOE_rC = 147 (15 mg NO_3^-/L)

Based on the above, the DS pointed concluded that conclusions drawn for potassium chlorate are also valid for sodium chlorate and vice versa.

Degradation

Sodium chlorate is highly soluble in water (696-736 g/L at 20°C for pH 4.49 to 8.70).

Sodium chlorate in aqueous solutions is known for its chemical stability under environmental conditions (Urbanski 1998).

Based on the chemical structure it is expected that sodium chlorate is resistant to hydrolysis. Due to its chemical structure, sodium chlorate is considered as stable in sterile water across the pH range and there are no relevant metabolites, degradation, or reaction products.

In the CLH report, the DS indicated that biotic conversion of sodium chlorate should not be assessed in standard OECD TG 301 tests for ready biodegradability and OECD TG 302 tests for inherent biodegradability because these tests only detect biodegradation of organic compounds under aerobic conditions.

Degradation of sodium chlorate in the Sturm test (OECD TG 301 B) using a specific analysis of chlorate was thought to be possible by L'Haridon (2003) because of the existence of anaerobic niches within the sludge particles used as inoculum. These anaerobic niches do occur in properly operated biological wastewater treatment plants (high activated sludge concentrations and low oxygen levels of~2 mg/L) but not in OECD TG 301 tests (low level of activated sludge and oxygen levels of >>9 mg/L). Moreover, the amount of biodegradable reducing agents in a standard OECD TG 301 test is also a limiting factor which prevents chlorate reduction.

The "Ready" biodegradability of sodium chlorate transformation can be demonstrated using the methodology of the Closed Bottle test (OECD TG 301 D) with one major modification (van Ginkel *et al*., 1995). The test was modified by adding excess amounts of reducing agents (fatty acids, amino acids, carbohydrates). A minor part of the reducing agent was oxidized with the molecular oxygen present in the bottles thereby creating anaerobic conditions. The test was inoculated with low concentrations of activated sludge, soil, digested sludge or dilutions of river and ditch water in line with the OECD TG 301. Complete removal of chlorate was achieved within 28 days with all inocula tested and most reducing agents.

The ease with which chlorate reduction occurs naturally is also demonstrated by Bryan and Rohlich (1954). The authors have used the chlorate reduction as a measure for the Biological Oxygen Demand (BOD). The study has shown that chlorate is rapidly reduced by microorganisms using organic compounds as carbon and energy source present in sewage.

The DS indicated that a valid ready biodegradability test result is not available for sodium chlorate because chlorate is an electron acceptor like molecular oxygen. Nevertheless, all aspects important for achieving a ready biodegradability test result i.e. ultimate (complete) biodegradation, rate of biodegradation and number and occurrence of competent micro-organisms present in "unacclimated" ecosystems and biological treatment plants have been investigated (see above).

Microorganisms are capable of growth on sodium chlorate in the presence of reducing agents under anaerobic conditions. The biodegradation pathway demonstrates that chlorate is reduced completely to chloride. The biodegradation kinetics of chlorate have been determined with mixed and pure cultures. The maximum growth rates of chlorate reducing microorganisms range from 0.04 to 0.56 h^{-1}, which is comparable or much higher than growth rates of nitrifying bacteria. Ammonium is oxidized readily in OECD TG 301 tests due to these nitrifying bacteria.

Painter and King (1983) used a model based on the Monod equation to interpret the biodegradation curves in ready biodegradability tests. According to this model, growth rates of competent microorganisms of 0.01 h^{-1} or higher do result in a ready biodegradation of the test substance. Reduction of chlorate has been detected in terrestrial ecosystems, fresh water, marine environment, compost, and aquifers.

Until recently, perchlorate and chlorate were thought to be primarily anthropogenic. Recent evidence makes a strong case for more widespread natural occurrence of perchlorate, outside of the long-established occurrence in caliches of the Atacama Desert. Improved sensitivity of perchlorate detection techniques shows widespread existence of ppb levels of

perchlorate. Not all perchlorate detected could be traced to anthropogenic sources. Natural perchlorate in soils is rare but occurs in other arid environments at levels up to 0.6 weight %. In the southern high plains groundwater, perchlorate is better correlated with iodate, known to be of atmospheric origin, compared to any other species (Dasgupta *et al*., 2005).

Natural perchlorate may be formed from chloride aerosol by electrical discharge and by exposing aqueous chloride to high concentrations of ozone (Bao and Gu, 2004; Bohlke *et al*., 2005). Information regarding the perchlorate formation process is, however, still largely unknown. Perchloric acid is the stable end product of the atmospheric chemistry because of its resistance to photolysis (Simonaitis and Heicklen, 1975) and occurs in aerosols in stratosphere of the earth at 0.5 to 5 parts per trillion (Murphy and Thomson, 2000). Perchlorate was also detected in rain and snow samples. This strongly suggests that some perchlorate is formed in the atmosphere and a natural perchlorate background of atmospheric origin should exist. In soils and surface waters perchlorate is reduced via chlorate. Chlorate is therefore part of natural chloro-oxy acid cycle. The existence of a chloro-oxy acid cycle does explain the enormous potential for chlorate reduction in the environment.

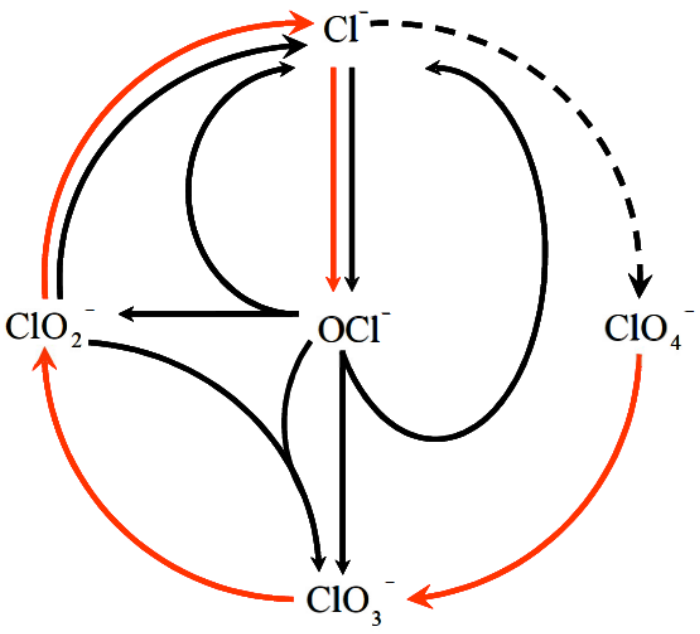


Figure 1: Chloro-oxo acid cycle. The dashed arrow represents the recent findings of perchlorate formation in aerosols. The red arrow are reactions catalysed by enzymes present in (per)chlorate respiring bacteria, nitrate reductases and peroxidases (formation of hypochlorite). The black arrows indicate chemical reactions occurring under ambient environmental temperatures.

In conclusion, the DS pointed out that these findings demonstrate the wide distribution of chlorate-reducing micro-organisms and that sodium chlorate is rapidly biodegradable. Although no standard tests are available for sodium chlorate, only tests deviating from OECD TG 301 TG methodology with respect to the absence of oxygen (van Ginkel *et al*., 1995) do indicate sodium chlorate is readily biodegradable. Hence, in applying a weight of evidence approach to this specific case it can be concluded that the substance should be considered as rapidly degradable for classification purposes.

Bioaccumulation

No measured data on bioaccumulation were identified by the DS. The DS concluded that based on the environmental fate and behaviour of the substance (the complete dissociation in water due to low dissociation constant and the high water solubility) no significant bioaccumulation is expected.

Aquatic Toxicity

In addition to acute and chronic aquatic toxicity studies on fish, invertebrates, algae, and aquatic plants using sodium chlorate, aquatic toxicity studies on marine algae using potassium chlorate are available in the CLP report.

Only relevant studies from each trophic level with the most conservative endpoint expressed as test substance (Na- or $KClO_3$) and as chlorate ion are summarised in the table below for acute and chronic aquatic toxicity (the key endpoints used in hazard classification are highlighted in bold). The toxicity values were adjusted by the DS for the molecular weight of the test substance or chlorate ion. All toxicity values are expressed as nominal values.

***Table**: Summary of relevant studies from each trophic level expressed as test substance and as chlorate anion for acute and chronic toxicity. Toxicity endpoint values are converted to sodium chlorate where necessary to complete the data set.*

Method/Test material	**Species**	**Endpoint**	**Toxicity value (mg/L)**		**Reference**
			$Na/KClO_3$	**ClO_3^-**	
Short-term toxicity					
EPA OPP 72-1 Sodium chlorate	*Oncorhynchus mykiss*	96h LC_{50}	>1000	>784	Study report (1991a) Key study
EPA OPP 72-1 Sodium chlorate	*Lepomis macrochirus*	96h LC_{50}	>1000	>784	Study report (1991b) Supporting study
OECD TG 203 Sodium chlorate	*Brachydanio rerio*	96h LC_{50}	>1000	>784	Study report (1991h) Supporting study
OECD TG 203 Sodium chlorate	*Pimephales promelas*	96h LC_{50}	>1000	>784	Study report (1993) Supporting study
In house protocol Sodium chlorate	*Oryzias latipes*	96h LC_{50}	2585	2027	Study report (1993) Supporting study
EPA OPP 72-3 Sodium chlorate	*Cyprinodon variegatus*	96h LC_{50}	>1000	>784	Study report (1991c) Key study
EPA OPP 72-2 Sodium chlorate	*Daphnia magna*	48h EC_{50}	>1000	>784	Study report (1991d) Key study
EPA OPP 72-2 Sodium chlorate	*Daphnia magna*	48h EC_{50}	1172	919.3	Study report (1995) Supporting study
In-house method Sodium chlorate	*Mysidopsis bahia*	96h LC_{50}	>1000	784	Study report (1991f) Key study
EPA OPP 122-2 Sodium chlorate	*Pseudokirchneriella subcapitata#*	72h E_bC_{50} 96h E_bC_{50}	129 133	101 104	Study report (1991e)

					Supporting study
OECD TG 201 Sodium chlorate	*Scenedesmus subspicatus*	72h E_bC_{50}	> 1592.3	1248.4	Study report (2004c) Supporting study
ISO 10253 guideline Sodium chlorate	*Skeletonema costatum*	72h EC_{50}	>1000	>784	Study report (2010a) Supporting study
According to own protocol Potassium chlorate	*Dunaliella tertiolecta*	15mg NO_3^-/L 72h E_rC_{50}	>1469	>1000	Stauber J.L. (1998b) Supporting study
According to own protocol Potassium chlorate	*Nitzschia closterium*	15mg NO_3^-/L 72h E_rC_{50}	>735	>500	Stauber J.L. (1998) Key study
OECD TG 221 Sodium chlorate	*Lemna minor*	7d EC_{50} (biomass growth) 7d EC_{50} (growth rate) 7d EC_{50} (biomass dry weight)	**73.7** 134 128	**57.5** 105 100	Study report (2003) Key study
U.S. EPA-FIFRA, Guideline 72-3 Sodium chlorate	*Crassostrea virginica*	96h EC_{50} 96h LC_{50}	1000 1000	784 784	Study report (1991g) Other information
ISO/DC 20666 Sodium chlorate	*Brachionus plicatilis*	96 EC_{50}	596	467	Study report (2010b) Supporting study
Long-term toxicity					
OECD TG 210 Sodium chlorate	*Danio rerio*	36d NOEC	≥ 500	≥ 392	Study report (2004a) Key study
OECD TG 211 Sodium chlorate	*Daphnia magna*	21d NOEC	≥ 500	≥ 392	Study report (2004b) Key study
EPA OPP 122-2 Sodium chlorate	*Pseudokirchneriella subcapitata #*	96h NOEC (cell growth)	62.5	49.0	Study report (1991e) Supporting study
OECD TG 201 Sodium chlorate	*Scenedesmus subspicatus*	72h NOEC (biomass) 72h NOEC (growth rate)	396.9 1592.3	311 1248.4	Study report (2004c) Supporting study
OECD TG 201 Sodium chlorate	*Scenedesmus subspicatus*	72h NOEC	2001	1569	Study report (1994a) Supporting study
ISO 10253 guideline Sodium chlorate	*Skeletonema costatum*	72h NOEC	≥ 1000	≥ 784	Study report (2010a) Supporting study
72 hours test according to own protocol based in ISO Sodium chlorate	*Phaeodactylum tricornutum*	NOE_bC NOE_rC	64 128	50 100	Study report (1994b) Supporting study
According to own protocol Potassium chlorate	*Dunaliella tertiolecta*	15mg NO_3^-/L NOE_rC (conducted at different NO_3 levels)	735	500	Stauber J.L. (1998b) Key study
72 hours test according to own protocol with potassium chlorate Potassium chlorate	*Nitzschia closterium*	15mg NO_3^-/L NOE_rC (conducted at different NO_3 levels)	147	100	Stauber J.L. (1998a) Key study

OECD TG 221 Sodium chlorate	*Lemna minor*	7d NOEC (biomass growth, growth rate, biomass dry weight)	**10**	**7.8**	Study report (2003) Key study
ISO/DC 20666 Sodium chlorate	*Brachionus plicatilis*	96h EC_{10} 96 NOEC	21 46	16.5 36	Study report (2010b) Supporting study

Note:
#- In the CLH Report the freshwater green algae *Selenastrum capricornutum* is cited which is formerly known as *Pseudokirchneriella subcapitata*.

Acute toxicity

For fish, six studies with six different fish species were available for sodium chlorate. The studies using freshwater fish followed EPA OPP 72-1 guideline for the rainbow trout (*Oncorhynchus mykiss*) and bluegill (*Lepomis macrochirus*), OECD TG 203 for zebrafish (*Brachydanio rerio*) and fathead minnow (*Pimephales promelas*) and an in-house test protocol for Japanese rice fish (*Oryzias latipes*). The test using marine fish *Cyprinodon variegatus* was performed according to EPA OPP 72-3. In all six studies a 96-h LC_{50} values of > 1000 mg/L were reported.

For sodium chlorate, two acute toxicity studies with *Daphnia magna* following EPA OPP 72-2 and one study for marine crustacea *Mysidopsis bahia* following an in-house method were available. In all three studies a 48-h EC/LC_{50} value of >1000 mg/L were reported.

Three acute toxicity studies with three different algae species using sodium chlorate and two studies with two different algae species using potassium chlorate were available. For sodium chlorate, the studies using fresh water green algae followed EPA OPP 122-2 for *Pseudokirchneriella subcapitata* and OECD TG 201 for *Scenedesmus subspicatus*, while the test using marine algae *Skeletonema costatum* was carried out according to ISO 10253 guideline. For potassium chlorate, both tests followed an in-house protocol but using different marine algae, *Dunaliella tertiolecta* and *Nitzschia closterium*. The lowest acute endpoint for algae is 72h E_bC_{50} of 129 mg/L for *P. subcapitata* using sodium chlorate, while in the case of potassium chlorate the lowest endpoint for algae is 72h E_rC_{50} of > 735 mg/L for *N. closterium*.

There was only one study following OECD TG 221 available using sodium chlorate for aquatic plants with the lowest value for acute toxicity to freshwater plant of 7-d EC_{50} value of 73.7 mg/L based on biomass growth for *Lemna minor*.

There were data available for other aquatic organisms, i.e. a 96-h LC/EC_{50} of > 1000 mg/L for eastern oyster (*Crassostrea virginica*) and a 96-h EC_{50} of 596 mg/L for marine rotatoria (*Brachionus plicatilis*).

From the available aquatic toxicity data, the DS concluded that aquatic plants are the most acutely sensitive taxonomic group. The lowest acute toxicity value 7d EC_{50} of 73.7 mg/L (biomass growth) for duck weed *L. minor* is above the classification threshold value of 1 mg/L, so classification of sodium chlorate as Aquatic Acute 1 is therefore not warranted.

Chronic toxicity

For sodium chlorate, there is one long-term toxicity study following OECD TG 210 for zebrafish (*Danio rerio*) available with a nominal 36-d NOEC value of ≥ 500 mg/L.

There was one chronic study following OECD TG 211 available using sodium chlorate for aquatic invertebrates, with a nominal 21-d NOEC value of ≥500 mg/L for *D. magna*.

Five toxicity studies with four different algae species using sodium chlorate and two studies with two different algae species using potassium chlorate were available. For sodium chlorate, the studies using fresh water green algae followed EPA OPP 122-2 for *P. subcapitata* and OECD TG 201 for *S. subspicatus*, while the studies using marine algae followed ISO 10253 guideline for *S. costatum* and own protocol based in ISO for *Phaeodactylum tricornutum*. In the case of potassium chlorate, both tests followed own protocol but using different marine algae, *D. tertiolecta* and *N. closterium*. The lowest endpoint for algae is a 96-h NOEC of 62.5 mg/L based on cell growth for *P. subcapitata* using sodium chlorate, while in the case of potassium chlorate the lowest endpoint for algae is 72-h NOE_rC_{50} of 147 mg/L for *N. closterium*.

In the CLH report, a mesocosm study with macro brown algae *Fucus vesiculosus* using sodium chlorate is available (Lehtinen *et al*., 1988) which was the basis for chronic aquatic hazard classification of the substance under the Dangerous Substance Directive (Directive 67/548/EEC). The study was considered not valid by the DS because the study was not performed according to standard laboratory methods and is not compliant with GLP. Several study deficiencies regarding method and materials (replicates, test organisms, seawater) were pointed out by the DS. In the study, 6-month EC_{50} value of 80 µg ClO_3^-/L and 6m LOEC value of 15 - 20 µg ClO_3^-/L for *F. vesiculosus* were reported. As the study was not performed according to standard methods and the duration of the study was much longer than standard duration, the results are difficult to compare to standard test results.

There was only one study following OECD TG 221 available using sodium chlorate for aquatic plants with the lowest value for chronic toxicity to freshwater plant 7-d NOEC value of 10 mg/L for *L. minor*.

There were data available for other aquatic organisms, i.e. 96-h EC_{10} of 21 mg/L for marine rotatoria (*B. plicatilis*).

Based on the results from the long-term aquatic toxicity studies, the DS concluded that aquatic plants are the most sensitive taxonomic group. The lowest chronic toxicity value of 10 mg/L for duck weed *L. minor* is above the classification threshold value of 1 mg/L. Therefore, the substance does not warrant a chronic classification. The DS pointed out that even if the substance would be considered as non-rapidly degradable this would not lead to classification for the chronic aquatic hazard.

Comments received during consultation in the ECHA website

Two Member States (MS) and five company-manufacturers provided comments. With the exception of one MS, all commenters agreed with the proposed no classification for environmental hazards by the DS. One MS pointed out that more evidence is needed to justify that the substance is rapidly degradable and has a low bioaccumulation potential, although this will not impact proposed no classification for the environment. For this MS, it is unclear how relevant the non-standard ready biodegradability study using excess reducing agents is to determining whether the substance is rapidly degradable. The MS also pointed out that fate and essentiality of the metal ion (and counter ion) were not fully considered in determination of the bioaccumulation potential of the substance.

Assessment and comparison with the classification criteria

Read across assessment

RAC agrees with the DS that data for sodium chlorate and potassium chlorate could be considered together for evaluation of environmental hazard of sodium chlorate based on the following:

- Sodium and potassium chlorate have the same molecular and structural formula except for the alkali metal;
- Both sodium and potassium chlorate dissociate in water to form the identical base structure and their respective counter-ions;
- Both substances are readily soluble in water;
- For aquatic chronic toxicity, a comparison of the available marine algae studies does not indicate a marked difference in the ecotoxicological profile (see toxicity values in table). There is a lack of toxicity of both substances to marine algae.

RAC agrees with the DS that toxicity of the test substance is expected to be related to the chlorate anion and not to the sodium or potassium cations.

Degradation

Sodium chlorate is highly soluble in water and is chemically stable in aqueous solution under environmental conditions (hydrolytically stable).

According to the CLP Guidance, Section II.4 (version 5.0, July 2017) for a purely inorganic compound such as sodium chlorate the concept of degradability as applied to organic compounds has limited or no meaning. Additionally, the degradation decision scheme in the CLP Guideline, Section II.4 (version 5.0, July 2017) is not directly applicable for inorganic substances, as is it was primarily developed for organics. Sodium chlorate is an inorganic substance and therefore the ready biodegradability and simulation testing from the decision scheme are not considered relevant because these tests only detect biodegradation of organic compounds under aerobic conditions. Furthermore, no valid standard ready biodegradability test result is available in the CLH dossier for sodium chlorate because chlorate is an electron acceptor like molecular oxygen.

No degradation of sodium chlorate was observed under experimental conditions (aerobic) in the Sturm test (OECD TG 301B). RAC notes that this method is not applicable for inorganic substances like sodium or potassium chlorate.

The Modified (adding excess amounts of reducing agents) Closed Bottle test (OECD TG 301D) indicated complete removal of chlorate within 28 days under anaerobic conditions (van Ginkel *et al*., 1995). The chlorate was reduced completely to chloride. The test shows that microorganisms carrying out chlorate reduction inhabit a variety of environments including rivers, sediments, soils and WWTP. However, significant biodegradation of chlorate by these microorganisms did not take place under aerobic conditions. The environmental fate of chlorate therefore depends on several factors, including the availability of suitable substrates and the absence of molecular oxygen and nitrate (oxygen and nitrate are utilized prior to chlorate by microorganisms). As a consequence, microbial reduction of chlorate will mainly occur in soils and sediments.

The study by Bryan and Rohlich (1954) demonstrated rapid reduction of chlorate by microorganism using organic compounds as carbon and energy source present in sewage under conditions that exclude atmospheric oxygen.

Two tests (OECD TG 301D and the study by Bryan and Rohlich (1954)) were performed under anaerobic conditions. According to CLP guidance (version 5.0, July 2017, section II.2.3.7) data regarding anaerobic degradation cannot be used in relation to deciding whether a substance should be regarded as rapidly degradable, because the aquatic environment is generally regarded as the aerobic compartment where the aquatic organisms, such as those employed for aquatic hazard classification, are found.

Consequently, RAC considers that here is no reliable evidence indicating rapid degradation of sodium chlorate, so the substance is considered to be not rapidly degradable for the purposes of classification and labelling.

Bioaccumulation

No measured data on bioaccumulation are available. The estimated octanol-water partition coefficient (log K_{OW}) log K_{ow} values of < -2.9 is available, which is below the trigger value of 4 given in the CLP Regulation. However, the log K_{ow} is not relevant for inorganic substances. RAC agrees with the DS that based on fate and behaviour of the substance (high aqueous solubility, complete dissociation in an aqueous solution) no significant bioaccumulation is expected.

Aquatic toxicity

Taking into account that toxicity of the test substance is expected to be related to the toxicity of the chlorate anion, RAC agrees that the data from potassium chlorate for aquatic toxicity endpoints could be considered for the classification of sodium chlorate. There are reliable experimental data on acute and chronic toxicity for all three trophic levels based on sodium chlorate and reliable data for marine algae for potassium chlorate available.

Acute aquatic toxicity

RAC is of the opinion that in case of sodium chlorate, reliable acute toxicity data are available for all three trophic levels (fish, invertebrates, algae, and aquatic plants). Aquatic plants are the most sensitive group, and the lowest result is a 7-d EC_{50} value of 73.7 mg/L for duckweed *L. minor*. RAC notes that all EC_{50}s/LC_{50}s for fish, invertebrates, algae, and aquatic plants (see Table) are above the threshold value of 1 mg/L. Therefore, sodium chlorate does not warrant classification for acute aquatic hazard. This is consistent with the conclusion of the DS.

Chronic aquatic toxicity

RAC considers that the mesocosm study with *F. vesiculosus* using sodium chlorate should not be taken into account for classification purposes due to the study deficiencies pointed out by DS. In addition, RAC acknowledges that REACH guidance (Chapter R.7b: Endpoint specific guidance, Version 4.0–June2017, p. 33) indicates the number of potentially conflicting elements in mesocosm study designs which could affect the reliability of the results. Therefore, RAC is of the opinion that this data should not be considered for the classification of sodium chlorate. Remaining data available in the CLH dossier is considered as relevant and reliable by RAC.

RAC is of the opinion that in case of sodium chlorate, reliable chronic toxicity data are available for all three trophic levels (fish, invertebrates, algae, and aquatic plants). Aquatic plants are the most sensitive group, and the lowest result is a 7-d NOEC value of 10 mg/L for duckweed *L. minor*. RAC notes that all NOECs/EC_{10} for fish, invertebrates, algae, and

aquatic plants (see Table) are above the threshold value of 1 mg/L. Sodium chlorate is considered not rapidly degradable and has a low potential for bioaccumulation.

RAC notes that for some species with acute toxicity data, chronic toxicity data is not available. However, although sodium chlorate is considered not rapidly degradable all toxicity endpoints for species with no chronic toxicity data are well in excess of 100 mg/L. Consequently, following CLP table 4.1.0(b)(iii), no chronic classification is derived via the surrogate approach.

Consequently, RAC concluded that sodium chlorate does not warrant classification for chronic aquatic hazard.

Overall, although RAC takes the contrary view to that of the DS in that potassium chlorate should be considered as not rapidly degradable based on the available data, **RAC agrees with the DS the potassium chlorate does not warrant classification for hazards to the aquatic environment.**

12 EVALUATION OF ADDITIONAL HAZARDS

This part was not evaluated in this dossier.

13 ADDITIONAL LABELLING

14 REFERENCES

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